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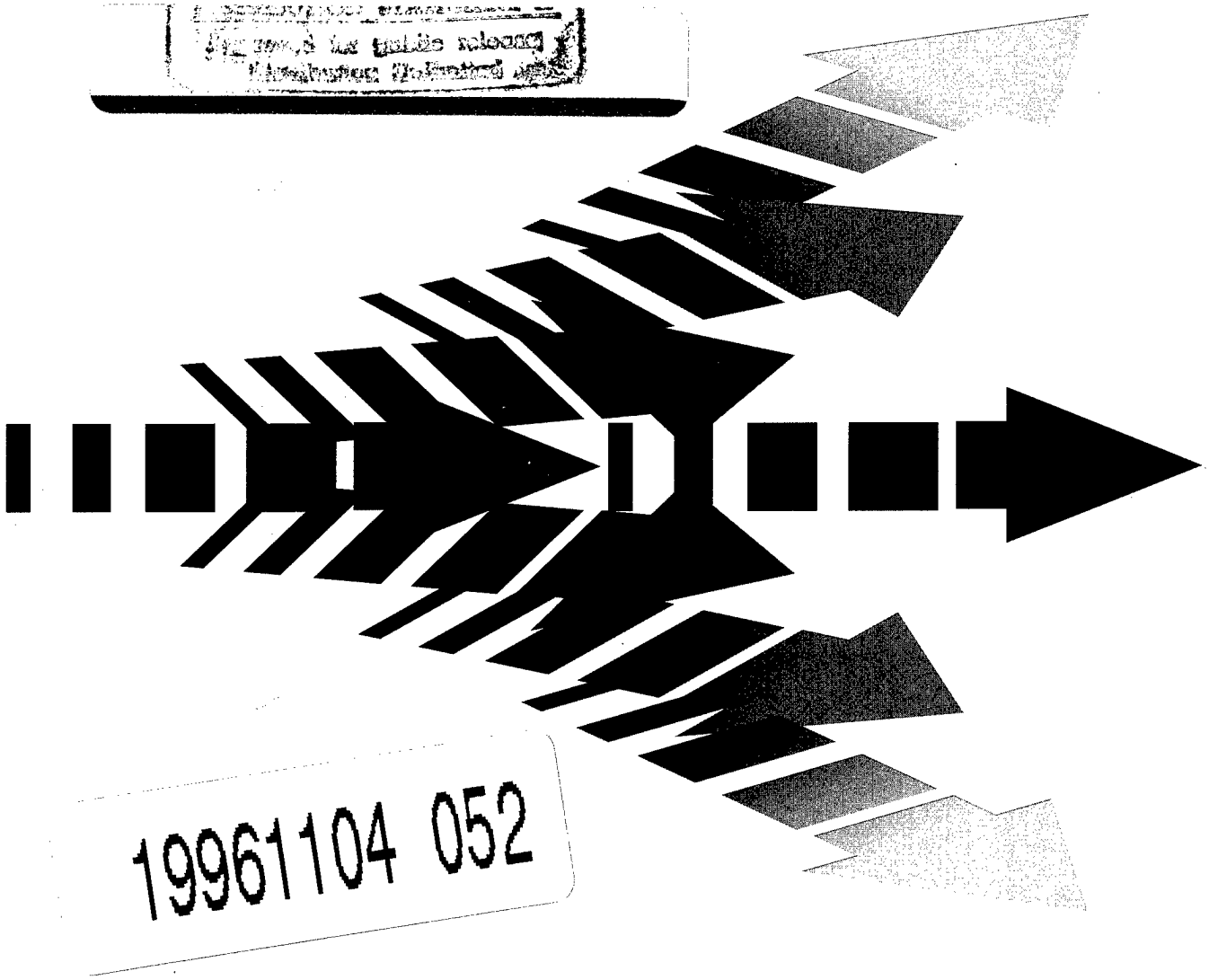
Water Resources Support Center
Institute for Water Resources

APPLIED RISK COMMUNICATION WITHIN THE CORPS OF ENGINEERS



March 1996

IWR REPORT 96-R-14

US Army Corps of Engineers®

APPLIED RISK COMMUNICATION WITHIN THE CORPS OF ENGINEERS

By

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March 1996 IWR Report 96-R-14

PREFACE

This report is a product of the U.S. Army Corps of Engineers' Risk Analysis for Water Resources Investments Research Program managed by the Institute for Water Resources which is a unit of the Water Resources Support Center. The report was prepared to fulfill work units in the research program concerning risk management strategy. These work units focused on developing and applying the concepts of risk preference and risk communication to water resources issues. The report conforms to the basic planning model and to the risk and uncertainty analysis recommendations presented in "Economic and Environmental Principles and guidelines for Water related Land Resources Implementation Studies" (P&G).

The purpose of this research project was to find methods of improving applied risk communication within the Corps of Engineers. To achieve this, IWR organized a workshop at which individuals from inside the Corps interacted with academic experts in risk communication and implementation of risk management programs in large organizations. The report contains a summary of the workshop discussions and some recommendations based on those discussions.

The report consists of three chapters, a bibliography, and six appendices. The chapters provide background information on the workshop, an overview of the papers presented, the discussions that followed, and the resulting recommendations. The first appendix describes the workshop participants, while the later five appendices are comprised of papers presented at the workshop.

This report was prepared by Planning and Management Consultants, Ltd. under terms of a contract with the U.S. Army Corps of Engineers Institute for Water Resources. Dr. David A. Moser was the contract manager for the report and is the manager of the Risk Analysis for Water Resources Investments Research Program. The Chief of the Technical Analysis and Research Division is Mr. Michael R. Krouse and the Director of IWR is Mr. Kyle Schilling. Mr. Robert Daniel, Chief of the Plan Formulation and Evaluation Branch, Planning Division, HQUSACE, Mr. Earl Eiker, Chief of Hydrology and Hydraulics Branch, Engineering Division, HQUSACE, and Mr. James Crews, HQUSACE, served as technical monitors for the research program at the time of this report's review. Numerous field reviewers provided valuable insights and suggestions to improve early drafts.

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I. INTRODUCTION

PURPOSE

The Corps of Engineers is encouraging (and even requiring) greater use of risk-based analytical methods in evaluating the engineering and economic performance of its proposed investments. To this end, the Corps perceives a need to improve its communication of risk information among groups within the Corps and with its customers. There exists a considerable volume of literature on the subject of risk communication, but much of its advice is either unrelated to Corps concerns or is too general for applied problems.

In a recent effort to improve its understanding of risk perception and communication, the Institute for Water Resources (IWR) commissioned a research study. That study culminated in the publication of a two volume report, *Guidebook for Risk Perception and Communication in Water Resources Planning* (October 1993). The first volume of this report examined the underpinnings of current theories and research with the goal of improving planning applications. The second volume comprises an annotated bibliography of risk perception and communication research (over 125 references).

Although the *Guidebook* provided an introduction to a burgeoning research area, it did not provide specific guidance such that Corps field personnel would be comfortable applying the principles discussed in it. To take another step in the direction of developing more specific guidance, IWR organized a workshop at which individuals from inside the Corps interacted over the course of two days with academic experts in risk communication and implementation of risk management programs in large organizations. This report contains a summary of the workshop discussions and some recommendations based on those discussions.

OBJECTIVES

The objective of this research project was to seek ways to improve applied risk communication within the Corps of Engineers. This was to be achieved by obtaining the advice of a small team of national and international experts in the field of risk communication. Each of the experts was asked to focus on the Corps risk communication problem and to deliver his or her recommendations in an informal workshop setting. The workshop was held at the Vanderbilt Institute of Public Policy Studies in Nashville, Tennessee on July 11 and 12, 1994.

ORGANIZATION OF THE STUDY

In the initial stages of the study two main groups of communication issues surfaced: (1) the communication of risk information throughout the Corps hierarchy, and (2) the communication of risk information to non-federal project sponsors. Improving the understanding of probability and the principles of risk assessment can be useful to both the Corps hierarchy and the local sponsor as can the development of improved risk information presentation techniques. Of more interest to the Corps are risk communication issues that reflect the Corps institutional structure (including the acceptance of risk analysis as an integral part of future Corps business) .

To address the issues surrounding risk communication within and beyond the Corps, the following team members were enlisted:

- William Cox, Department of Civil Engineering, in collaboration with Leonard Shabman, Department of Applied and Agricultural Economics, both of Virginia Polytechnic Institute and State University.
- Mark Abkowitz, Department of Civil Engineering and Management of Technology, Vanderbilt University
- John Payne, Fuqua School of Business, Duke University
- Detlof von Winterfeldt, Institute of Safety and Systems Management, University of Southern California
- Lee Wilkins, School of Journalism, University of Missouri
- Donald MacGregor, Decision Research

Additional and valuable commentary was provided by V. Kerry Smith, Department of Economics, North Carolina State University. The workshop agenda, list of attendees, and brief biographical sketches of the study team are provided in Appendix A.

Prior to the workshop, the team members were provided with an array of information to help them focus on risk communication within the Corps. All team members received:

- a copy of the *Guidebook for Risk Perception and Communication in Water Resources Planning*
- a statement describing the major risk communication issues of concern to IWR
- summaries of two Corps guidance documents directing the use of risk analysis by field staff (for flood damage reduction and major rehabilitation studies)

This material provided the study team with an understanding of (1) the concerns of the Corps with respect to risk communication, (2) the state of knowledge of risk perception and communication within the Corps, and (3) the type of risk information that current Corps risk analysis will yield.

OUTLINE OF THE REPORT

The main body of the report comprises an overview of the papers presented at the workshop and of the ensuing discussion. This overview provides the main basis of recommendations presented in the subsequent section. Five of the presented papers are included as appendices B-F.

II. OVERVIEW OF THE RISK COMMUNICATION WORKSHOP

This workshop was an event unique for its combination of small size, extreme informality, interdisciplinary mix of participants, and presence of field and headquarters representatives of the Corps. However, the workshop did not produce any massive breakthroughs in risk communication nor any magic formulae for successful internal or external risk communication; not because the participants were ill-equipped or not trying, but because **the formulae and recipes do not seem to be out there**. What it did produce seems best approached on two levels, as sets of lessons and challenges.

The first level was immediate, practical, and unsurprising. It contained the closest approach to formulae that the Corps is likely to find in this field. The basic message on this level was: **Given a tough and changing external and internal environment, the Corps is making the right moves to improve its risk communication performance**. Some minor improvements were suggested, but no participant made a case for dramatic changes.

On another level, however, there was evidence that the Corps concerns tap into much deeper problems than how lay individuals deal with probabilities, or whether engineers can be trained to view risk-based design as professionally responsible, or even whether the mass media can ever be more (or less) than thorns in the side of "rational" planning and design. **These problems cut close to the heart of how our society makes collective decisions about imposing collective bads on or providing collective goods to itself**. They involve such knotty related concerns as the gray area between public education and manipulation by propaganda, and the apparently inevitable need for the mass media and their audiences to focus on the particular event and on specific victims rather than on the non-events of successful operation that leave no victims.

The remainder of this chapter is divided into four sections. The first attempts to introduce the concerns of the workshops; the last a very general comment on the longer run future. The second section spells out in more detail the "first-level" lessons and suggestions. The third section exposes the difficulties involved in solving risk communication problems.

BACKGROUND

The world has changed over the past 3 or 4 decades. From the Corps point of view, in particular, there have been huge changes in the politics of, and hence the decision processes surrounding, water projects and water resource management. The inter-regional and inter-industry subsidies implicit in the massive public water projects of the 1930s through the '50s were successfully attacked by the net payors in the 1970s and '80s. The resulting requirement for local "sponsorship" (i.e., money) drastically reduced attractiveness of such projects to Congressmen and Senators. Subsequently, the Congressional attractiveness of the Corps were also reduced. As the Corps special relationship to senior legislators and key committees weakened, the Corps found itself faced with new challenges—or, perhaps more accurately, heightened versions of old challenges. Two of the most important were the needs (1) to cultivate and accommodate potential local sponsors, and (2) to become more obviously a team player within the executive branch of government.

At the same time, special provisions in new legislation (especially environmental), changes in

federal administrative procedures, and accumulating judicial decisions made it much easier for narrow but organized interests to challenge, delay, and even stop proposed direct activities of federal agencies or activities of private parties that involved federal agencies. Furthermore, these challenging interests both reflect and encourage a general public attitude that rejects expert pronouncements and assurances; especially when these appear to come from those closely associated with big business or big government. It may not be as quick and simple as "once-burned/twice-shy", but generations have learned from nuclear power, Vietnam, and Watergate that disinterested experts are thin on the ground—so thin, that assuming every expert to be a spokesperson for some special interest group seems prudent.

Specifically related to risk, these general trends and attitudes have led to a reduced willingness to accept assurances that any prospective risk is as low as experts claim; and into a willingness and ability to create challenges to such proposed risks (primarily through litigation). None of this should be read as singling out the Corps for criticism or as implying that earlier generations of Corps leadership acted cynically. Wherever the blame, the result is that people laugh at the statement, "I'm from Washington and I'm here to help you." In this new era, the Corps faces an especially tough time in making a case for its role in water resource management.

Finally, adding extra communication complexity is increased by our expanding knowledge of just how hard it is to convey information about risky situations to lay people, be they voters or jurors, legislators or judges. In fact, beginning in the 1950s and '60s with the work of Gilbert White and his colleagues, evidence has accumulated that, independent of skepticism about the motives of government agencies, people find it hard to understand probability densities for such events as droughts and floods.

Thus, the risk communication challenge the Corps is seeking to overcome is multi-dimensional. In particular, it is only partly technical.

LESSONS FROM THE WORKSHOP

The previous section painted, albeit with a very broad brush, some trends that have impinged on the Corps and have affected the way it is pressured to operate. On balance they have made the Corps' environment much less friendly and have raised the stakes for every decision, and even every major subsidiary calculation. The challenges of being a team player within the administration, an ally by local sponsors, at least a potential friend by legislators, and at worst a misguided actor in the environmental drama, must create substantial internal tension and external friction. The fact that the Corps operates in a world of stochastic events exacerbates but certainly does not account for these challenges. Indeed, for the purposes of the workshop, the opposite direction of influence seems more significant; Communicating about risk, internally and externally is hard, only partly because of technical difficulties. More importantly, it is hard because risk analysis and its application become the focus of the tensions and frictions just described. The recognition lies behind a major conclusion of the symposium.

- There are no magic formulae for persuading field personnel to do useful risk analyses, nor are there others for persuading lay people and legislators to accept what the Corps' analyses suggest as the "best" way to design or operate a project.

The Corps leadership seems to currently recognize and act on the general elements of positive advice they were offered by workshop participants:

- Trust is the necessary condition for effective communication.

- Communication implies listening as well as transmitting.

- Experimentation with media and message, form and content, is necessary because we know so little about how particular messages will be understood when received.

- It is important that there be visible advocates for the use of risk analysis and management techniques at the highest organizational levels.

- Aggressive efforts must be made at internal education to spread the word out and down from these key advocates.

Some special Corps problems were explicitly recognized in the presentations, leading to specific suggestions for incrementally improving current efforts.

- Domination of the field offices and district and division staffs by traditionally trained civil engineers led to the notion that the Corps should try to influence the future via engineering curriculum, by requiring new hires to have had a course in probability and risk analysis.

- The stress on multiple reviews of plans and projects at higher and higher levels puts a premium on easily reproducible results and hence on rules of thumb (reliability or performance standards). For example, levee is designed according to rules which govern its height relative to a well-defined flood height, because the slopes of its faces must meet particular standards, and so forth. Admittedly it is easier to check for compliance with such straightforward rules than to follow and approve complicated multivariate simulations or optimization models that subject uniquely designed levees to synthetically generated flow records of long duration and keep track of the results. This realization led some participants to suggest fewer, more rigorous, reviews as part of internal policy revisions aimed at encouraging use of risk analysis.

- The absence of externally imposed rules, analogous to *Principles and Guidelines*, for choosing among (or even eliminating any subset of) alternatives subject to a full-fledged risk analysis (so that entire distributions of possible events are generated) was seen as a hindrance. This led to suggestions that the Corps should push for explicit choices along these lines to be made by Congress. (More is said about this in the third section of this overview).

Another, perhaps even more important flaw in the current process—another discouragement to the explicit application of risk analysis and management—was recognized in the matter of "failure". That is, designing facilities or operating rules to cope with stochastic events means that unless infinite costs are accepted, events will someday occur that overwhelm the design: levees will be topped or washed out, spillway capacities exceeded, agricultural water storage exhausted in the middle of a growing season, or below-dam oxygen levels reduced below those necessary for fish survival. *Ex ante* these events have been taken into account, and the prospect of their occurrence is one design pressure resulting in more costly designs. But things look different *ex post*. Then there will likely be a public search for someone (or some organization at least) to "blame", someone whose decision led to "too low" a levee or "too small" a reservoir. The old cliché about penny-wise/pound foolish will be trotted out. The role of the mass media in this process was also recognized. "Victims' stories" are more saleable than analytical

explanations. And who would consciously create victims by underdesigning?

Nothing in the way of an antidote to this threat emerged from the workshop. Indeed, observations about the credo of the engineer professionals only reinforced the power of prospective "failure" as a discouragement to the embracing of risk analysis.

A few other, quite specific suggestions are worth mentioning:

- The business school case-study method was recommended as a model for the Corps' internal communication (education) efforts.

- The notion that it would be desirable for the Corps to explain itself, its analytic approach, and its management philosophy, outside the stresses of a particular project decision surfaced more than once. Target audiences might include the media, local decisionmakers, and special interest groups (e.g., environmentalists). Any such effort would probably require creation of entirely new tools, such as professional videos to carry people along rather than lose them in a mass of jargon and technique.

To repeat, however: overall, the Corps efforts, both internally and externally, as they were understood by the participants, received good marks. No one expressed or implied disagreement with the broad philosophy, organization, or approach that the Corps has adopted.

DIFFICULTIES BEYOND THE CORPS

If the Corps is pursuing most of the strategies recommended by workshop participants for better risk communication, why does there seem to be frustration with lack of progress on the part of the internal advocates? One observation, is that it takes a long time to change a corporate culture. This section, however, will concentrate on other observations, that may be less comforting and only some of which will imply actions within the control of Corps leadership. Together, these observations suggest that there is much more at stake than corporate culture and media relations. Collective risk management, and communication about it, is an activity that probes the weaknesses of collective decisionmaking more generally.

First consider two relatively easy matters: terminology that needs work and assumptions that need examination.

For example, "risk analysis" itself may mean explicitly taking account of stochasticity in any of a number of ways. It is the "explicitly" that mattered, not the specific technique. The contrast was with the use of standards that conceal randomness behind a facade of apparent certainty. In this view, risk analysis could be taking expected values of, say, flood damages for levees of different heights (and costs) and recommending that height (along with other design features, perhaps) that minimized the sum of costs and damages.

For other participants risk analysis meant taking explicit account of the dispersion of outcomes. Their preferred method for doing this seemed to be the Monte Carlo simulation, and the recommended platform was *@ Risk*, with which many Corps employees are familiar.

- Whatever the Corps wants to make the phrase mean is fine. But this choice ought to be supplemented by clear guidelines spelling out when risk is worth analyzing. Thus, for example, the navigation maintenance and rehabilitation programs implicitly seem to recognize that decisions involving a few million dollars at a facility can reasonably be analyzed using expected values. This must be because:

- the variance in outcomes under alternative decisions is small enough

- the difference in analytical costs is great enough

But this implicit recognition is still only implicit and has not been codified. This leads to fresh arguments each time a new piece of the analytical method is exposed to comment.

Related discussion at the workshop often returned to the contrast between "standards" and risk analysis. The usual assumption was that standards are too conservative because they reflect an abhorrence of "failure." The other assumption seemed to be that standards are an obstacle to implementation of risk management and to rational communication with local sponsors.

This second attitude seems unnecessarily absolute and ought to be explicitly examined and suitably qualified. For many decisions involving modest cost and modest variance in either damage or benefit, standards may short-circuit analyses with low payoffs. Where this will apply will probably have to be discovered through background analysis. Such analysis would also allow modification of standards to fine tune those that survive. Standards determined too conservative could be relaxed, and vice versa.

- Corps leaders may already be aware of the two observations just made but they may benefit from more exposure and support. In the face of stochasticity a spectrum of planning responses is in order—from rules of thumb (standards) to full blown risk analysis. The rules for particular sorts of decisions should be chosen from along the continuum depending primarily on the variance of possible outcomes (in money and safety terms) and on the amount of potential cost savings relative to the incremental costs of more sophisticated analysis. Guidelines for this choice should be created and publicized.

Another unexamined assumption is that there are ways of communicating results of risk analyses to decisionmakers that are clearly superior.[1] It is difficult to support this notion. If it is hard to convey the meaning of an expected value, how much harder it is to get across not just a single full distribution of outcomes, but the sensitivity of outcomes to interrelated design alterations? Density and distribution plots and "tornado" diagrams can be helpful. But the attraction of worst cases would not be so strong if it were easy to comprehend the multiple dimensions of output generated by a Monte Carlo simulation with sensitivity analysis.

This observation is related to another one that gets us into deeper difficulties: there is no explicit guidance on choosing among alternatives that have been subject to detailed risk analysis. If there were, presentation of results would not be so vexing, for the guidelines for decisions would define, implicitly or explicitly, the dimensions of importance. However, the lack of such guidance is no accident or oversight. Congress would much rather avoid giving such guidance, preferring their criticize outcomes. When guidance is given it will be of the kind seen in environmental and health and safety legislation—protect the most sensitive individual; allow no introduction of any animal carcinogen; reduce risk to de minimum levels. It is not politically palatable to go on record as not protecting someone in some situation.

The political necessity of criticizing "failure" is just one of many forces that push for having actual performance look 100 percent safe, when the imposition of collective (public) bads is at stake. Two others, both discussed in the workshop papers, are media criticism and the specter of liability suits. For the Corps, and particularly for individuals within the Corps, the latter need not be a tremendous concern. Sovereign immunity should apply. But local sponsors may well be more

sensitive, for lower jurisdictions appear to be much more vulnerable to such ex post actions.[2]

The media problem, however, appears to be a major stumbling block, for it interacts with and reinforces the political aversion to explicitly condoning less than perfect performance. The Corps, by itself, cannot change this. There is probably little comfort in knowing that analogous disconnections between *ex ante* intentions and *ex post* reality plague other areas of public policy. Thus, to take just one example, consider welfare reform. The idea of a time limit on welfare payments appeals to those who believe the welfare rolls to be loaded with long-term slackers. But consider what the ex post reality would look like as the media reported on the plight of hungry mothers and kids, camping out on heating grates. These would be victims of heartless government bureaucrats; not slackers. By these standards, the Corps problems may actually look a bit less daunting. After all, while rational dam and levee design may result in some actual deaths as well as home destruction and so forth, it will not condemn any identifiable victim to inevitable suffering and death. There will be criticism when a flood exceeds the capacity of physical control measures, but the criticism directed against the builders of those measures will tend to recede with the water. As the physical world returns to something like normal, criticism will begin to focus on disaster relief efforts, especially grant and loan programs, which can never function as smoothly, open pipes for money because the fear of fraud creates obstacles.

Returning at last to risk communication concerns but without entirely leaving the realm of the political, consider content, manipulation and the decision process. The workshop discussions, when this triplet of issues came up, tended toward optimism. The accepted notion was that the widest sort of public involvement should be sought, even to the *a priori* granting of veto power to *ad hoc* assemblages organized around particular proposals for collective good provision. That is, such institutions as Department of Energy's "Site-specific Advisory Boards" would in this view be given power to shape policies and projects. This can be seen either as a supplement to or an end run around the familiar organs of political decisionmaking. However it is characterized, this general approach is clearly an attempt to short-circuit the often endless rounds of legal challenges to the specifics of policies and projects. Whether it is a viable strategy for the long run remains to be seen. The very ad hoc quality that allows inclusion of potentially obstructive groups will inevitably leave other groups feeling unfairly un- or under-represented.

Communicating with whatever groups—organized or disorganized, ad hoc or traditionally legitimated—was said to be a matter of developing trust, of being completely honest and open. The rub comes in defining what is honest and open communication for public decision purposes when we know as much as we do about risk perceptions and heuristics. That is, we know enough to be at least dangerous, if not to be completely effective; for we recognize such tricks of the human brain as the establishment of powerful reference points based on the incidentals of "framing" rather than on a universally understood structure for a particular problem. Which framing is, then, the "honest and open" one? Which counts as manipulation? Is the Corps obligated to supply two, four or six framing and let the public (as represented by advisory boards or legislators) decide which to pay attention to? Even more basically, should the strategy be to provide every conceivable piece of information from risk analysis, or is that likely to look like a cynical attempt to overload the circuits? But if there is to be editing, what gets edited? We have, in effect, an infinite regress of decisions concealed behind the seemingly benign facade of open and honest.

In summary, risk communication in the context of collective risk management decisions is not just a technical problem and cannot have a neat technical solution. Rather, the decision on

what to communicate, to whom to transmit and to whom to listen, is part and parcel of designing not the project but the decision process itself. That is the ultimate reason it is so hard to communicate risk.

CLOSING THOUGHTS ON THE LONGER RUN

If the previous section is correct in its analysis of the larger context for risk communication, it follows that we can expect the nature of the problem to evolve along with our collective decision-making institutions. It would be convenient if the path of that evolution could be foreseen with some confidence; but, not surprisingly, the opposite is true. At best it seems possible to discern two broad alternative paths. One draws from the common pendulum metaphor. It says that distrust of the traditional forms of government will soon peak, as we discover the flaws inherent in all the alternative experiments in more "participatory" approaches. To push the notion a little harder, imagine that over time the currently fashionable cynicism about leaders and experts is damped as memories of some of the classic outrages fade and as individuals learn that they really cannot flout the investigative media. In such a future, risk communication could become a bit more technical challenge and a bit less of a political one.

A contrasting view of the future would be one that sees further fragmentation and experimentation, based, for example, on the prediction of massive interactive TV capabilities. Then the informal plebiscites represented by talk shows might actually become the long promised global (or regional) town meetings: instant referenda on any issue, with vast connected capacity to transfer information directly to the mass of citizenry; dueling experts in every living room, with participation limited only by boredom and time available away from employment. The possibilities for manipulation and counter manipulation became nearly limitless. The temptation to create propaganda, in the classic sense may be irresistible, and we have to trust in a new instant marketplace of ideas, in which misinformation can be identified and addressed before the message becomes a memory.

Either future will hold more promise if citizens are, if fact, better educated as well as computer literate. From the perspective of risk communication, there could usefully be an effort to introduce young children to the fundamental concepts of risk and uncertainty at least as early as they are introduced to elementary algebra and geometry. If subjective probability, independent events, density and distribution functions, expected values, and a few other key notions were conveyed early on, there might be less scope for manipulation, whatever the future turns out to hold.

III. RECOMMENDATIONS

The previous chapter raised many issues regarding the communication of risk information within and external to the Corps and stressed that hindrances to successful risk communication are both technical and political. Recognizing that the Corps has limited control over many factors affecting water resource risk communication, the following recommendations focus on immediate and long term solutions which the Corps can implement.

1. The Corps should continue and increase its risk education effort.

   a. For discussion makers within the Corps:

      - Add a training course to the ACTEDS requirements for key positions.

      - Schedule high level workshops on risk management and communication at several locations around the country during each of the next two fiscal years.

      - Organize informal discussions in Washington for Headquarters and other management personnel members of the relevant media (for example, those who would report on large scale flooding along the Ohio or Mississippi).

   b. For operating and analytical personnel within the Corps:

      - Make training on risk information presentation techniques part of a mandatory partnering session during the project feasibility or design process.

      - Add a risk communication training course to the ACTEDS requirements for Corps employees.

   c. For new hires into the Corps:

      - require evidence of completion of a course including material on risk analysis and management.

   d. For potential non-federal sponsors:

      - offer a PROSPECT course for state, county, municipal (or other relevant organization) level employees in a convenient location and at a mutually convenient times.

   e. For media and state, county and local politicians and decision makers:

      - Schedule regional workshops for the informal exchange of views on risk questions and risk management techniques.

2. The corps should allow and encourage IWR to set up an external team of experts in risk analysis, management, and communication that would be available to participate in the workshops and discussion sessions called for in recommendations 1a and 1e above; that would bring back to IWR at regular intervals their perceptions of relevant advances in these fields; and that would be called on for quick consulting in preparation of or subsequent reviews of project approval analysis.

3. The corps should consider revising the project approval process to include fewer but more rigorous reviews to help discourage use of easily checked rules of thumb and encourage use of more complicated analysis of available risk tradeoffs.

4. The Corps should develop and promulgate formal guidance on the level and sophistication of analysis appropriate to particular problem settings. This guidance could initially be based on type of project and estimated cost. Later it could be changed to reflect results of the cast studies recommended in #5 below.

5. The Corps should enhance its own understanding of the processes and interplay of risk analysis management and communication. Promising directions include:

   - After-the-fact reviews of project design and approval process.

   - Examinations of media and political responses to particular types and sizes of "failure" (floods, grounding, fish kills, etc.)

   - Exploration of the contrasting implications of a few case-study project of different approaches from common design rules of thumb, through simple expected value calculations, to elaborate Monte Carlo simulations.

   - Focal groups of state and local politicians to explore the Corps' image as it relates to risk management in their bailiwicks.

APPENDIX A
AGENDA AND STUDY TEAM BIOSKETCHES

AGENDA

APPLIED RISK COMMUNICATION WORKSHOP

Nashville, Tennessee
July 10-12, 1994

Sunday, July 10, 1994

6:30 p.m. Reception/cookout (very casual) at the home of Cliff Russell

Monday, July 11, 1994

8:00-9:00 Continental breakfast at VIPPS

9:00-9:30 Introductions by Cliff Russell, VIPPS Host and Workshop Chairperson and David Moser of the Corps' Institute for Water Resources

9:30-10:30 **William E. Cox, Civil Engineering, Virginia Tech:**

Overcoming Barriers to the Management of Risk by the U.S. Army Corps of Engineers

10:30-10:45 Break

10:45-11:45 **Mark Abkowitz, Civil Engineering and Management of Technology, Vanderbilt University:**

Risk Management and Communication

11:45-1:00 Lunch at VIPPS

1:00-2:00 **John Payne, The Fuqua School of Business, Duke University:**

Risk Analysis, Risk Communication, and Risky Decision Making

2:00-3:00 **Detlof von Winterfeldt, Institute of Safety and Systems Management, University of Southern California:**

Communicating Risk

AGENDA (Continued)

APPLIED RISK COMMUNICATION WORKSHOP
Nashville, Tennessee
July 10-12, 1994

3:00-3:15 Break

3:15-4:15 **Lee Wilkins, School of Journalism, University of Missouri:**

Communicating with the Public about Risk: What You Can Expect from the Mass Media

4:15-5:15 **Donald MacGregor, Decision Research:**

Risk Perception, Communication, and Community Relations

6:00 Cocktails and Dinner Buffet

Tuesday, July 12, 1994

8:30-10:00 **V. Kerry Smith, Economics, North Carolina State University and University Fellow, Quality of the Environment Division, Resources for the Future**

10:00-10:15 Break

10:15-11:00 General Discussion

11:00-11:30 Comments/Wrap-up: Cliff Russell and David Moser

Each speaker will provide a 40 minute presentation; an additional 20 minutes are allotted for discussion.

BIOGRAPHICAL SKETCHES OF EXPERT GROUP APPLIED RISK COMMUNICATION WORKSHOP

Mark D. Abkowitz has an extensive background in management of technology, with a specialization in risk assessment, hazardous materials transport, emergency management, intelligent mapping, distribution logistics, and accident analysis and prevention. As founder and president of an environmental risk management consulting firm and university professor, he has been involved in research and product development, executive training, and technology transfer for shippers, carriers, and regulators. He has been integrally involved as architect and project manager for a variety of technical studies and software development initiatives performed for the hazardous materials industry. Dr. Abkowitz has authored numerous journal publications and study reports, and chairs and serves on several national and international transportation committees.

William E. Cox is Professor of Civil Engineering and Coordinator of the Hydro systems Division at the Charles E. Via, Jr. Department of Civil Engineering at Virginia Tech in Blacksburg, Virginia. He received a Ph.D. in Civil Engineering from Virginia Tech in 1976.

His research and teaching focus on water policy and management, including both water-supply management and water-quality protection. Special emphasis is placed on institutional arrangements for water-management decision making. In the area of water supply, special attention has been given to institutions for allocation of offstream water use and maintenance of natural environmental conditions within aquatic ecosystems. In the case of water-quality management, institutions of protection of groundwater and surface water quality from nonpoint sources of pollution have been the primary focal point.

Recent teaching has included graduate and undergraduate courses in the areas of water planning, water law, and the legal and professional aspects of engineering. Recent research has included institutional arrangements for watershed management, resolution of water-transfer conflict, and protection of groundwater from agricultural contamination. Over 125 papers have been contributed to a variety of refereed journals, books, conference proceedings, and other publications.

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BIOGRAPHICAL SKETCHES OF EXPERT GROUP APPLIED RISK COMMUNICATION WORKSHOP

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APPENDIX B
OVERCOMING BARRIERS TO THE MANAGEMENT OF RISK BY THE U.S. ARMY CORPS OF ENGINEERS

OVERCOMING BARRIERS TO THE MANAGEMENT OF RISK

BY THE U.S. ARMY CORPS OF ENGINEERS

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INTRODUCTION

The U.S. Army Corps of Engineers, through its civil works program, designs, constructs and often operates large water control projects. These projects are a critical part of the national infrastructure, but project failure may have significant adverse economic and safety consequences. What costs are warranted to reduce the likelihood of project failures? How is this decision to be made in a complex, decentralized, engineering organization like the Corps? The approach traditionally taken by the Corps has relied substantially on centralized development of engineering standards for uniform application across the agency.

Uniform standards are a relatively common means of balancing the costs and risks of various undertakings. Since a standard specifies minimum requirements to be met in a given situation, an acceptable level of risk is implied in each standard. Uniform standards dictate the minimum level of *project performance* in response to natural events. Performance standards define the minimum forces which a project must withstand without failure. An example of a performance standard would be that all levees should protect an area from at least the 100 year flood flow. In this case the probability of failure is expected to be zero up to the 100 year flow. Some performance standards are defined as a joint product of the natural and human system. Thus, the safe yield of a water system, as a performance standard, is a result of an evaluation of the flow of a river, the volume of storage, and the projected consumption of water. For example, the safe yield standard might be to meet the demand projected for 30 years into the future during recurrence of the drought of record with a reduction in storage of 75 percent.

Uniform standards also are used to establish the minimum *project reliability* needed for meeting any given performance standard. Reliability standards are meant to assure that the structural features of the project will, with some degree of probability, withstand the performance forces. Reliability standards are developed for single components of the structure, such as a levee slope. Of course, these standards interact for the whole project as a system of component parts to establish overall project reliability.

The original development of a standard may have involved a consideration of cost and associated failure risks. In the case of Corps standards, however, *explicit* risk assessment does not appear to have been a part of standards development. Standards have tended to focus on the objective of keeping risk low, but actual levels of risk inherent in specific standards have generally not been determined. In fact, standards development has not been based on explicit policy defining acceptable risk.

Of course, the very nature of the application of uniform standards means that no explicit consideration of risk versus cost is made for individual projects. The uniform standard approach to managing project risk has the implementation advantage of obscuring the risk versus cost value judgment implicit in a standard and creates the appearance of a completely objective process.

This can be misleading. Dave Pye, as quoted by Henry Petroski in his book To Engineer is Human (1985), makes the point that there can be no true objectivity in engineering design.

> All designs for use are arbitrary. The designer or his client has to choose in what degree and where there shall be failure. Thus, the shape of all things is the product of arbitrary choice. If you vary the terms of your compromise--say more speed, more heat, less safety, more discomfort, lower first

> cost--then you vary the shape of the thing designed. It is quite impossible for any design to be the logical outcome of the requirements simply because, the requirements being in conflict, their logical outcome is an impossibility.

Failure to recognize this reality, and to persist in the use of uniform standards, means that a fundamental design and budget decision is delegated to a position where there is limited opportunity for review. As a result, the actual balance between cost and risk of failure is not recognized for any given project. Furthermore, the uniform standard results in different risk exposure among different projects. Ironically, the uniform application of standards results in non-uniform failure risk among projects.

In recent years, the Corps has begun to experiment with a new approach to project safety: risk-based decision making. Guidance on risk assessment has been developed from a comprehensive research program, training for field staff has been initiated, and the requirement to use risk assessment methods in dam safety and flood control project planning has been put in place.

Risk analysis, or risk-based decision making, is usually recognized as having the two components of risk assessment and risk management (Ruckelshaus, 1983). *Risk assessment* requires the measurement of "risk" as the product of the likelihood of an event and the socioeconomic and ecological consequences of that event. Risk assessment requires describing the distribution of possible natural and socio-economic events that may stress the project so that probability distributions are used to characterize the likelihood of project failure.

Risk management is the exercise of judgment in deciding the socially appropriate response to the risk measured by a risk assessment. In simplest terms, that choice may be to accept the risk or to bear a cost to reduce it. Costs may include increased financial outlays, non-monetary environmental costs or changes in project design which reduce project benefits. Risk management judgments, made at various points of the planning process, address the acceptability of increased costs to reduce the likelihood and consequences of project failure.

In an idealized risk versus cost decision process, risk assessment is the product of an analytical exercise which requires both measurement, using state-of-the-art techniques, and interpretation of the results for communicating the essence of the analysis to those responsible for decision making. The purpose of the assessment is to form a menu of choices for a decision maker. Presented with an assessment, the decision maker chooses, thus making a risk-cost judgment.

Risk-based decision making in the Corps would substitute for uniform standards in project design. Instead of uniform application of standards across all projects, individual project performance and reliability *goals* would be chosen after a risk assessment of the likelihood of occurrence of various project forces, the consequences of project failure, and costs of reducing either the likelihood or consequences of failure.

The risk analysis approach differs substantially from traditional Corps design practice. Therefore, its adoption by the agency may confront significant obstacles. *The objective of this paper is to recommend organizational reforms that can advance the use of risk-based decision making within the Corps. Key results and recommendations are found throughout the paper and are presented in italics.*

The paper begins by describing the traditional Corps decision process based on application of standards. In this same section, the recent Corps move toward risk-based decision making is described and the use of standards in other decision

making processes is reviewed. This discussion is presented to demonstrate that the Corps is not unique in its reliance on standards or in facing pressures to employ risk-based decision making. Third, barriers to technical risk assessment in the Corps are described, and general recommendations to overcome such barriers are made. These technical risk assessments must support explicit risk management decisions. Therefore, the fourth part of the paper describes barriers to risk management and makes general recommendations to reduce these barriers. Following these discussions of barriers to risk assessment and to risk management, an "informed consent" model for relating engineering decisions to the public is described and its application to the Corps is recommended. A conclusion provides a summary of key findings.

TRADITIONAL CORPS STANDARDS-BASED DECISION MAKING

The Corps is a decentralized agency that operates through 10 Divisions that are further divided into numerous districts. Individual project planning and design is initiated at the district level, and the Corps has long recognized the need for some degree of autonomy and design flexibility at that level. But design flexibility is bounded by relatively complex central guidance and review of project analyses. This central design guidance and review takes two forms. First, the Corps publishes manuals and other documents specifying rules and practices that must be followed in project design. Second, this formal guidance is supplemented with informal rules contained in oral traditions perpetuated as part of the agency's organizational culture. Together, these formal and informal design practices can be termed "engineering standards" which are applied to both performance and reliability.

One of the most important forms of guidance is the written text of the engineer manual (EM). The following statement from the EM addressing design of breakwaters and jetties is typical of the role prescribed for EMs (EM 1110-2-2904, sec. 1-8):

> This manual presents factors that influence the location of breakwaters and jetties, the determination of the type and magnitude of forces to which the structures will be subjected, the selection of construction materials, and the choice of structure types that best suit a particular location. Even though design methodologies are based on the latest state-of-the-art developments, they are not intended to replace individual engineering initiative. Departures from the manual which are in accordance with sound engineering principles and judgment are acceptable for usual situations; however, to prevent misunderstanding between the designer and reviewer those departures should be explained and supported.

Although such statements indicate that EM provisions are not absolute requirements, the fact that alternative approaches must be justified creates a strong incentive for the designer to follow procedures as presented. In addition, the tone and style of the typical EM suggest that compliance is expected.

The EMs present design guidance in the form of performance standards, which specify results to be achieved by a given design, and reliability standards, which specify minimum dimensions and other features to be incorporated into a given design irrespective of the performance to be achieved. An example of a performance standard common to several EMs is the specification of maximum flow to be safely passed by the structure being designed. The following provision from an EM addressing the hydraulic design of navigation dams is typical (EM 1102-2-1605, sec. 3-3(c)):

> The maximum experienced flood of record is established for each project, but the dam should generally be designed with adequate capacity to pass the probable maximum flood (PMF).

Current Corps written design guidance makes clear that satisfaction of performance standards takes precedence over decisions based on cost or benefit considerations. The following quotation indicates that cost minimization is a secondary consideration (EM 1110-2-1611, sec. 14-1):

> Engineering is a science that has as its purpose satisfying the wants and needs of people. In accomplishing this objective, the aim of the engineer should be to attain maximum results in the most economical manner. This cost optimization should provide the basis for selecting a project level of protection or evaluating alternative designs once project functional adequacy and safety are assured. In other words, only after design criteria have been achieved (minimum level of protection) can cost optimization be applied.

Reliability standards, which are often in the form of rules of thumb that specify minimum values for elements of design, are more pervasive than performance standards. In practice, the distinction between performance and reliability standards is often hard to make because they jointly determine the projects likelihood of failure (The term "Reliability" as used here is consistent with use by the Corps, but may have a different definition in the engineering profession). Indeed, to select performance and reliability standards is to select a probability that the project will fail if subjected to some level of system loading from natural forces (e.g. flood flows, droughts, and earthquakes) or human activity (e.g., realized demand exceeding projections). As examples, consider the following provisions from the EM addressing hydraulic design of deep draft navigation projects (EM 1110-2-1613):

> Sec. 5-9 - minimum clearances between vessels and channel bottoms
> Sec. 7-4 - minimum clearances between ships moving in two-way traffic
> Sec. 7-5 - minimum clearances between navigation lanes and channel banks
> Sec. 7-9 - minimum radii for curves in navigation channels
> Sec. 7-11 - minimum distances between channel curves
> Sec. 8-1 - minimum size for boat turning basins

These examples of required "minimums" are not exhaustive of the standards in this EM but do indicate the type of constraints presented to the project designer.

This approach to standards setting has also imposed opportunity costs on the nation as forgone benefits of projects that were not built because the project did not meet some standard of the Corps. An example is provided by the flood damage reduction program where the Corps has an implied policy of building only "fail-safe" projects under certain conditions. The design flood for flood damage reduction projects is the PMF whenever a project involves potential for catastrophe, defined as (ER 1105-2-20, sec. 3-5):

> An event causing sudden and widespread misfortune, destruction or irreplaceable loss; a catastrophe may be said to occur when many human lives are endangered, human lives will likely be or have been lost, or urban property damage occurs extensively enough to cripple activities in the area.

If application of the rule results in high costs, and benefits are not adequate to justify the cost, the

Corps traditionally has been likely to recommend no project although a project providing a lower level of protection that may fail under a PMF may have been less costly and might have been justified. In the interest of preventing a highly unlikely project failure, significant benefits that might be realized from a different project design are forgone. The balance between risk and cost that arises from this practice has never been openly debated because of the absence of an explicit risk management strategy.

Development of the Corps design standards and practices is not well documented in the published histories of the agency, but the evolutionary process is likely to have seen the growth of design guidance in response to particular failures and problems with facilities as they arose. Such episodic development could be expected to encompass a variety of *worst case situations* presented by the special circumstances of individual projects. To the extent that standards developed for such worst cases are adopted for universal application, the resulting design guidance reflects a high degree of risk aversion and has resulted in higher cost designs.

Perhaps of more importance than formal standards in regulations, circulars, and EMs, are the ways in which standards are perpetuated and enforced by less formal means. Standards are contained in agency conventions and traditions that collectively constitute the agency's organizational culture. An agency's culture includes values, beliefs, and underlying assumptions that may have dropped out of consciousness and therefore go unquestioned. Together, these elements form a way of seeing and predispose agency personnel to certain patterns of behavior and decision making. Organizational culture is perpetuated through screening of prospective employees, formal training programs, organizational socialization, the sharing of agency traditions and myths, the ways in which budgets are allocated from higher to lower organizational elements, and other forms of verbal and nonverbal communication (Ott, 1989). In the Corps, technical review of projects provides one of the strongest means for communicating acceptable agency practice.

The influence of organizational culture may be as significant as formal standards in perpetuating and enforcing traditional agency practices. Therefore, changes in organizational culture may be the most effective way to change traditional practices. If an effort to advance risk assessment approaches is to succeed, factors as obvious as the way the review process is structured, the way budgets are allocated and the commitment of the organizational hierarchy may be as important as writing new rules or technical training. Indeed, recent changes in agency practice have begun to change the organizational culture of the Corps.

Challenges to Traditional Design Standards

A significant shift in Corps policy was the establishment in the 1980s of the NED plan— the plan that maximizes net National Economic Development benefits, consistent with environmental constraints—as the priority plan for budgeting of new projects. The NED plan was expected to replace project performance standards in design. Application of a NED performance standard means that performance expected for flood control structures would vary with the economic conditions in the area protected and with project costs. Of course, there has since been resistance to NED as a performance standard, and the persistence of traditional performance standards in many EMs, combined with the strong admonition to follow the EM guidance, remains.

Another change which challenged the routine application of standards was the 1986 revision to the process of evaluating the hydrologic safety of dams. Rather than rely on the PMF as an arbitrary

standard in repair of dam safety deficiencies, the agency promulgated dam safety evaluation guidelines which followed closely the concepts articulated by a study committee convened by the American Society of Civil Engineers (ASCE) for evaluating procedures to determine the appropriate spillway design flood.

The ASCE committee, which focused on dams of diverse sizes and ownership, classified dams into three categories for purposes of recommending an approach to spillway design. The following describes each category and the committee's recommendation for spillway design (Task Committee on Spillway Design Flood Selection, 1988, p. 17):

> Category 1 contains dams whose failures, based on reconnaissance-level assessments, cause a loss of life or other social or economic losses which unarguably warrant the use of the PMF as the safety design flood.
>
> Category 2 contains dams where a reconnaissance-level assessment of the failure consequences is not adequate to select a safety design flood. The proposed procedure includes the process for selecting an appropriate design flood. The procedure is predicated on the premise that all non-category 3 dams should be designed for the PMF and that only after rigorous analysis is it possible to conclude that a lesser flood is appropriate.
>
> Category 3 contains dams which are usually small and of low cost and whose failures, based on reconnaissance-level assessments, will produce damage confined to the owner. Default safety design floods are suggested.

The analyses proposed for categories two and three included quantitative risk assessment. This recommendation was a departure from traditional Corps procedure, but a variant of risk assessment was adopted for *all* existing Corps projects regardless of category and has since been used to set budget priorities.

Another development challenging the traditional approach has been increasing concern for project cost. Being funded by general tax revenues, the Corps does not owe its continuing existence to the sufficiency of revenues generated by investment in its development projects. Disassociation of expenditures from returns eliminates the direct feedback that would stimulate interest in trade-offs between cost and failure risk. In general, a publicly funded agency would have less incentive to employ risk-based decision making as part of an effort to maximize returns on investments. But changes in the Corps approach have been motivated by pressures from others who are concerned about cost.

Until recently the practice of developing standards intended to maximize safety without regard to cost had gone unquestioned. Non-federal contributions had been relatively small, so project beneficiaries have had little reason to question designs incorporating high project cost. Cost discipline has not been present in risk management choices made on performance and reliability standards.

Now the traditional design approaches are being challenged under current budgetary conditions and newly initiated financial arrangements for water projects. Federal budgetary restrictions are placing new emphasis on controlling federal expenditures, and local interests facing increased cost sharing under the Water Resources Development Act of 1986 (P.L. 99-662) are seeking to reduce overall project costs in order to reduce the local share. Therefore a new cost discipline is coming to the Corps design process. This need for cost discipline is a direct

incentive for expanded application of risk assessment followed by explicit risk management.

Application of Standards by Others

Within the Federal government, many agencies apply standards as a routine way of managing program decisions. Government regulatory standards control private sector products and activities that may affect public health and safety. Often these standards are encoded in law, but Congress has imposed differing standards among activities with different implied risks and costs. *Therefore, the Corps use of uniform standards which may lead to very different risks and costs across projects and decisions has been common among government agencies.*

Some standards are intentionally set to be extremely risk averse in their application; in fact, some congressionally mandated standards attempt to reduce certain risks to zero. For example, a provision of the Food, Drug and Cosmetics Act known as the Delaney Amendment (21 U.S.C.A. sec. 348(c)(A)) prohibits use of any chemical additive found to induce cancer when ingested by man or animal. This unqualified prohibition is an attempt to eliminate the risk of cancer from additives.

Other standard setting approaches allow balancing of risks and costs. For example, the Federal Insecticide, Fungicide and Rodenticide Act authorizes the Administrator of the Environmental Protection Agency to approve a requested pesticide registration unless the produce will cause "unreasonable adverse effects on the environment" (7 U.S.C.A. sec. 136a (c)(5)). The Toxic Substances Control Act mandates the Administrator to establish controls over chemical substances whose manufacture or use presents "an unreasonable risk of injury to health or the environment" (15 U.S.C.A. sec. 2605). The Safe Drinking Water Act allows the administrator to establish maximum contaminant level (MCL) goals for drinking water contaminants (which must be set at a level where no known or anticipated adverse health effects will occur) and legally enforceable MCLs as close to the MCL goals "as is feasible" (42 U.S.C.A. sec. 300g-1(b)(3)). The Clean Water Act allows the Administrator to establish wastewater treatment facility performance standards based on determinations such as performance of "best available technology economically achievable" (33 U.S.C.A. sec. 1311(b)(2)(A)).

Within the discretionary authority provided by the above provisions, a balancing of costs and benefits in setting standards may be employed (see Baram, 1980). Admittedly, data and analytical limitations make assessing these benefits and costs difficult. As a result, actual standards that are set for particular situations can be excessively "risk averse" because, in the presence of uncertain knowledge of the probability and consequences, the tendency has been to make risk-cost tradeoffs using worst case assumptions throughout the analysis. *Therefore, in using worst case assumptions the Corps practices in setting performance and reliability standards are not unique among Federal agencies.*

However, under the pressures of budget cost and complaints about "unfunded mandates" there is now a movement in the Congress to expand the analytical attention to higher quality risk assessment as a basis for standard setting. The Corps experience of having its standards challenged by cost pressures is being repeated with other Federal agencies.

Standards are also created by non-federal governments, a primary example being building codes. In practice, most local governments rely heavily on model codes developed by three primary private organizations: Building Officials and Code

Administrators International, Inc. (BOCA), the Southern Building Code Congress International, Inc. (SBCCI), and the International Conference of Building Officials, Inc. (ICBO). Use of these three model codes is generally divided along geographical lines, with the BOCA code prominent in the East and Midwest, the SBBCCI code prominent in the South, and the ICBO code prominent in the West (ASCE Administrative Committee on Building Codes, 1991).

Standards incorporated within model codes are often adopted from the private sector. Consider the BOCA code, for example (ASCE Administrative Committee on Building Codes, 1991):

> The 1991 BOCA National Building Code places great reliance on the use of standards produced in the private sector. This code references 295 standards developed and published by 43 organizations.

This practice substantially blurs the distinction between public sector and private sector standards.

Within private firms and organizations, standards are a means of ensuring consistency among decisions, simplifying routine decision making by eliminating the need to consider all aspects of each case anew, and controlling quality of products. For example, voluntary standards are frequently employed to promote interchangability of product parts and generally to facilitate commercial transactions. In this sense the reasons for having standards are similar to the reasons standards are pervasive in the Corps.

Private standards-setting organizations typically do not employ benefit-cost analysis and have often operated without substantial data concerning history of losses from the activity to be subjected to standards. Private standards often are established by committees whose members primarily represent firms who would be most directly affected by a proposed standard. Consumer interests have been reported to play a minor role in the process (Cheit, 1990, p. 177). Since acceptance of a proposed standard is usually by consensus, potential exists for risk taking to be a characteristic of standards developed in the private domain, or at least for more explicit consideration of risk reduction versus cost to be a consideration in standards development. Such a consideration has often been absent in the Corps approach to standards development.

Indeed, the Corps approach to standards development often does differ from the private sector, with possible consequences in terms of cost. Consider the approach taken by Underwriters Laboratory, a major product testing and certification organization, with respect to the treatment of consumer misuse of products. According to Cheit, certain mishaps in use are taken into account, but "UL generally assumes that consumers are literate, obedient, and only occasionally clumsy" (Cheit, 1990, p. 105). By contrast, Corps standards often base design on assumed low levels of performance by project users and/or equipment deficiencies that limit performance. Consider the following provisions relating to designs of navigation facilities (EM 1110-2-1611, sec. 3-3 and EM 1110-2-1613, sec. 2-2, respectively):

> Design of navigation facilities should consider that special steering devices generally will not be available and that some towboats will be operating with power insufficient for the safe handling of their loads. Safety of the project will depend on the size and maneuverability of the vessels using the waterway, size and type of channel and navigation aids provided, effects of current and wind, and experience and judgment of the pilots. Since the human factor (judgment and reaction of the pilot) is involved and is difficult to evaluate,

potentially hazardous conditions should be eliminated insofar as practicable.

These quotations indicate a Corps tendency to design projects in an attempt to compensate for the possibility of human management error and equipment limitations. Such a design parameter can increase project costs substantially.

Case studies (Cheit, 1990) provide some support for a conclusion that the private sector is more responsive to the cost versus risk reduction tradeoff than the Corps. However, a more open acceptance of risk in private decision making is not always the situation. In fact, examples of very risk averse private standards are not uncommon. Possible explanations for risk aversion include desire to forestall governmental regulation, special influence of certain safety conscious groups such as firefighters, and influence of testing labs who develop standards without reliance on the consensus approach and who have financial interests associated with certification of products subject to strict standards. *Therefore, in the private sector, as in the Corps, when decision making on risk management is divorced from cost, the standards applied may be more risk averse.*

BARRIERS TO RISK ASSESSMENT IN THE CORPS

In comparison to applying standards, risk assessment requires a new and specialized expertise, special analytical tools, and in the longer term may require new data bases. All these requirements translate into increased planning costs, at least for the short term when the Corps field staff and tools are being developed.

To assure that study costs are not excessive, risk assessment should be applied selectively rather than as comprehensive substitution for use of standards. When considering doing a risk assessment (RA) in lieu of a standard, one possibility is that RA may result in new information that will improve project economic or environmental performance. However, the other possibility also exists—that the risk assessment effort, and the associated study costs, will yield no change in a project design. When, then, is risk assessment warranted? How much of limited planning funds should be allocated to risk assessment? The answers to these two questions by themselves require a risk assessment followed by a risk management determination. In this case the "risk" is that limited study funds will be expended on studies which prove to have no bearing on the final project plan.

The question of when a risk assessment is warranted in place of standards application requires judgment on the part of the study manager. The payoff from risk assessment for the study manager is, in part, based on the managers judgment that the risk assessment will be technically "successful." Such success depends upon staff expertise, available analytical approaches, and quality databases.

Staffing and Analytical Limitations

The relative absence of risk assessment requirements within the Corps project evaluation has resulted in limited development of staff capability to conduct risk assessments and has resulted in a lack of necessary analytical tools for risk assessment. Recent efforts in the Corps risk research program are beginning to address these limitations by constructing risk assessment software specific to applications for the Corps program and by providing classroom training as well as direct technical assistance to project planners in district and division offices. Continued development of necessary analytical tools would be a relatively straight forward process, as long as adequate research and development resources are provided.

Another more fundamental problem must also be addressed. Engineering structures such as those constructed and operated by the Corps must be designed by professional engineers, but the traditional education of engineers may not provide adequate preparation for statistical analyses that underlay risk assessment. In many engineering courses, statistical procedures are included as computational formulae that are integrated into deterministic calculations of project design. Therefore, the student may rarely be exposed to the non-deterministic calculations characteristic of risk assessment.

Overall exposure to statistics in engineering programs may be inadequate. Consider the criteria of the Accreditation Board for Engineering and Technology for inclusion of statistics in engineering curricula (1990, sec. IV. C.3.d.(a)):

> Additional work is encouraged in one or more of the subjects of probability and statistics, linear algebra, numerical analysis, and advanced calculus [emphasis added].

The absence of a minimum requirement for statistics in engineering curricula may result in less than adequate background in subject areas essential to risk assessment.

Remedying these staffing deficiencies may require several actions on the part of the agency. First, internal classroom training programs in all aspects of risk assessment should be continued and expanded. Second, expanded headquarters capability to provide direct technical assistance on specific project analysis may be needed. This type of technical assistance is now being provided by the research labs who have developed the risk assessment guidance that is in place, so the resources for that capability might be expanded. Third, the Corps might advance recommended changes in the educational requirements for the engineering profession as a whole. Toward this end, one immediate action would be to add course requirements in statistics to the list of courses required for employment by the Corps.

An alternative approach to remedying field staff deficiencies is to replace the traditional decentralized planning and design approach of the Corps with centers of planning expertise. In this reorganization, these centers would be locations within the Corps where risk assessment models would be run and assessment results written for use in risk management. The responsibility of the district office would be to become familiar enough with the needs of the risk assessment methods that they could provide assistance in data base assembly for their particular project of concern.

Such a consolidation of expertise may be warranted for several reasons. First, the number of projects is declining, and building staff capacity in all districts in the face of a shrinking workload may not be justified. Second, by centralizing analytical capability, the costs of studies can be reduced because scale economies will be realized and "learning time" reduced. Third, the costs of project review will be reduced because of greater assurance of reliability of study results if done by a specialized staff. Last, the cost of developing specialized staff at one location will be lower than enhancing staff capabilities in all districts.

Data Bases

Risk assessment requires extensive data sets capable of generating probability distributions. Such data bases are available to the Corps in only one area—hydrology. Historical rainfall and runoff records have been routinely used in the past for a variety of project planning and design purposes and have been the basis for the application of many engineering standards. In fact, in the area of flood

control benefit assessment, the new Corps risk assessment procedures rely on these data for much of the risk assessment work.

Beyond the hydrologic records, data bases that might be applied for risk assessment are quite weak, and in the presence of weak data bases, all agencies—the Corps included—are likely to make worst case assumptions and deny the very purpose and potential of risk assessment as a decision aid. Therefore, the technical success of risk assessment can be advanced in the Corps by an effort to improve the data base.

Remedying data deficiencies will require several actions and changes in the Corps. An increased agency budget must be directed at the single purpose of data base development. However, in order to know which data to develop, the agency must first develop the tools that will be used for risk assessment of particular project purposes. Data base development can be cost effective only with a clear definition and understanding of the models to which the data will be applied.

Three specific data base development activities can direct the agency effort, once these specific data requirements are precisely defined. First, while the Corps has extensive experience with operating and managing water projects, systematic records of operation and maintenance which can be used for determining probabilities of project non-performance have not been maintained or analyzed. The result is that actual data on past project performance are not readily available to planners who are designing new projects or rehabilitating older projects. Also, many large water projects not built or operated by the Corps may provide data that to date have not been used. The Corps should immediately begin to organize historical records on its own projects operation and maintenance, as well as in cooperation with other project owner/operators. Of equal importance, the Corps should develop new record-keeping procedures on project performance that will generate future data suitable for risk assessment.

If historical records can not be analyzed, or if new data collection is not practical, needed data might be generated by creating and running physical models to simulate operation for various facilities under different stresses. In the past, this type of modeling has been expected to produce single point estimates of values so that standards can be applied to produce fail safe design. This type of physical modeling may offer the possibility of developing data sets that might be used for probability estimation, much as animal tests are used as analogues to human risk measurement in environmental risk management decisions. And, as with the animal test data, the physical modeling data may be used as inputs to more extensive mathematical models that incorporate test data with historical data.

BARRIERS TO EXPLICIT RISK MANAGEMENT IN THE CORPS

Adoption of explicit risk management decision making for the Corps project designs will mean a more conscious consideration of risk versus cost tradeoffs by those charged with decision making. Such open consideration of risk management choices will be constrained by a range of impediments, extending beyond staff and data limitations on risk assessment. These constraints on adoption of risk management arise within the agency's organizational culture and from general characteristics of the decision making environment in which the Corps operates. Relaxing these constraints will require changes on the part of both the Corps and the public.

Studies of organizational behavior during recent years have emphasized the complexity of factors

that influence and motivate individuals who make decisions within administrative units of government. These studies have dispelled the view that personnel within government organizations have no personal motivations, but simply serve some broad conception of the "public interest." Indeed, *goals of public agencies are likely to be defined only in general terms and may be conflicting because of creation of differing responsibilities and programs over time. Agencies (and therefore the individuals within agencies) must complete the definition process either explicitly or implicitly to make them operational.*

Therefore individuals within government organizations at times act in accord with their own interpretation of the public interest, but may also confound that motivation of serving the organization with personal goals such as maximizing salary and other benefits, professional reputation, power, and a variety of other factors (Jackson, 1983, p. 216; Breton and Wintrobe, 1982, p. 6).

Of the various factors that motivate Corps water planners and the Corps as an agency, four seem especially significant for establishing the willingness to employ risk assessment to make tradeoffs of cost versus risk: (1) maintaining professional and agency image, (2) public expectations, (3) expectations of the parties involved in project review, (4) concerns for liability. The following sections discuss these factors affecting the willingness to employ explicit risk management.

Maintaining Professional/Agency Image

An important element in the conduct of professional practice is upholding commonly accepted standards and expectations associated with a particular profession. Consistency with the cultural norms of a profession is essential to attainment of respect and reputation and the associated advancement in career.

A basic aspect of the engineering culture is the perception of a close relationship between the activities of the profession and the general public welfare. This perception is perpetuated by a variety of means. For example, the first fundamental cannon from the Code of Ethics of the American Society of Civil Engineers states that: "Engineers shall hold paramount the safety, health, and welfare of the public in the performance of their professional duties."

As a consequence of this self view as guardian of public safety and welfare, the engineer tends to be risk averse with respect to large projects whose operation and/or failure can have widespread adverse human impacts. This orientation supports a tendency to develop designs that minimizes failure risk to the extent possible within the outer limits of economic feasibility. The decision to accept greater risk in exchange for a cost savings is likely to be viewed as averse to the public interest *and* a violation of professional standards.

This behavioral norm is not explicitly stated but can be derived from the general admonition to always use "best engineering judgment." To the extent that balancing of risk and cost in a risk management decision process is seen as mandating the acceptance of higher levels of failure risk, the risk management process may be rejected as a violation of the engineer's duty to the public.

Doubt about the propriety of risk analysis where public health and safety are involved is reflected in the chapter title "The Deceptive Allure of Risk Analysis" in Samuel Florman's (1987) book The Civilized Engineer. Noting that estimates of costs and impacts of activities often differ widely, Florman urges caution in substitution of formal risk analysis for less mathematically precise decision-

making processes. He states: "Just as the beginning of wisdom is self-knowledge, so is the essence of engineering rationality a recognition of its proper limits."

Engineers in both the public and private sectors are likely to have the same inherent tendency to view risk analysis as inconsistent with professional standards. But the profit motive of project engineers in the private sector will act as a countervailing force likely to prevent the degree of conservatism adopted by a public sector engineer.

Operating simultaneously with the desire for advancement of professional reputation is the motivation to maintain a high level of public respect and stature for the employee's organization. Preservation and advancement of the organization's stature, while not a formally stated organizational objective, is generally a fundamental operational objective (Benveniste, 1983). In the case of the Corps, this objective is closely related to the professional advancement objective, and pursuit is likely to involve the same behavior with respect to treatment of risk. As in the case of advancing the individual's professional reputation, advancing agency stature is likely to lead to risk averse behavior since any failure of an agency project would cause substantial harm to agency stature. Avoidance of the costs of such failure in the form of a loss of agency stature will be perceived as more important than the potential rewards of reducing investment costs by finding a balance between risks and costs (Thompson and Wildavsky, 1982).

Reducing the effect of this constraint would require increased public acceptance of explicit use of risk assessments by the Corps in making tradeoffs of cost versus risk. In addition, professional organizations, through their codes of ethics and other guidelines for professional practice, must endorse a more explicit balancing of failure risk and project cost as acceptable practice. Without this generally supportive environment, project planners can be expected to resist more explicit risk management. The issue is discussed further later in the paper where one means to achieving professional and public acceptance is explored in more detail.

Public Expectations

A key factor influencing the Corps' (and others') handing of risk is public understanding of risk and public attitudes toward risk versus cost decisions. These public understandings and attitudes apply in general and toward Corps projects in particular. Of special concern for the Corps is the public tendency to view losses associated with failure of constructed facilities as greater than equivalent losses from strictly natural events. In addition, losses would likely be perceived as greater than equivalent cost savings that resulted from incorporation of risk analysis into design (Blomkirst, 1987). These perceptions will act to support public acceptance of risk averse design practices now in place.

A second problem arises from the public's unwillingness to accept quantification of some of the impacts of project failure or inadequate performance within a risk assessment. In some cases, the calculation is relatively straightforward and acceptable (e.g., costs of delays associated with inadequate navigable capacity). However, if project failure has the potential to produce loss of life and/or adverse social and environmental effects, assignment of monetary value to such events is resisted. To be sure, such monetary valuation is done for certain purposes (e.g., determination of compensation for human health effects and environmental damages in judicial proceedings) (see Kahn, 1989), but these are efforts done for the purpose of establishing monetary damages *after* an adverse consequence has occurred. To use such calculations to determine the acceptable degree of

risk aversion in relation to cost of risk reduction may lead to charges of callousness.

A first step toward greater acceptance of explicit risk management will be increased public understanding of probabilities and the general concept of risk-based decision masking. Although some movement in this direction appears to have occurred, significant change is likely to be a long-term process for which the Corps can only be a part. The Corps can, however, address one of the public objections by not placing money values on some of the adverse consequences of project failure. Instead risk assessments might best describe (not use a single measure) failure consequences in physical or other terms.

Expectations in the Project Review Process

The ability of Corps planners to conduct risk assessments and incorporate explicit risk management into project design is constrained by their expectations of acceptability within the project review process. Parties who participate directly in project review or provide guidelines for project planning include Congress and the executive branch of government in addition to the Corps hierarchy itself.

In Congress

Early Corps projects were undertaken on the assumption that they furthered national development without benefit of explicit assessments of costs and benefits. The Flood Control Act of 1936 (Act of June 22, 1936, 49 Stat. 1570) is generally considered to contain the first formal requirement that certain projects have benefits in excess of their costs. However, this act's language was a statement of general intent more than a demand for precise calculations.

In fact, for many years the Congress generally deferred to the Corps on the technical merits of projects, directing its attention to allocating a limited budget among competing projects which were all assumed to be technically sound and of appropriate levels for public safety. For example, Congress has not established criteria for dependability of service for navigation projects or water supply projects as well as not specifying level of protection for flood control projects. Failure to specify the level of service delegated this decision to the agency (Simon, 1976).

The lack of congressionally mandated performance criteria for the Corps projects is theoretically offset by the requirement that each Corps project must be authorized and have funds appropriated by Congress. The Corps has been somewhat unique in the directness of its relationship with Congress. Maass (1974) notes that the president traditionally has had limited control of the Corps, with the agency reporting directly to Congress, or more specifically, to certain congressional committees and individual members of Congress. Maass quotes from a 1934 letter from the Secretary of War to the President in which the Corps was described as "an agency of the legislative branch" (p. 74). Maass describes several unsuccessful attempts to reorganize water management responsibilities to establish greater executive control, including attempts to divest the Army of its water management functions. In spite of this direct relationship between Congress and the Corps, however, Congress has not established performance criteria for projects authorized for Corps implementation.

Congress, contrary to its recent actions in the field of environmental protection, continues to avoid specifying the level of performance to be achieved by water management projects. Such goals could be contained in a statement of risk management policy that provided guidelines for the desirable balance to

be achieved between the risk of failure and project cost. The recently released report from the Clinton administration on the 1993 flood recommends a step in that direction. Also, recent controversies over potential flooding of the American River (CA) have forced the Congress to address the acceptable level of risk that the nation may want to accept for major cities such as Sacramento CA. To date, however, Congress has given little direction to the Corps for balancing the risks and costs of water projects.

In the Executive Branch of Government

Currently, Principles and Guidelines (P&G) (Water Resources Council, 1983) provides planning guidance for the Corps as well as the Bureau of Reclamation, the Soil Conservation Service, and the Tennessee Valley Authority. The P&G suggests examination of uncertainty affecting plans and consideration of a limited number of reasonable alternative forecasts that may appreciably affect design, however, no specific procedures or requirements for risk analysis are included.

P&G does offer a guideline for project scaling stating that a severable component of a project should be included only if its incremental benefits exceed the additional costs. This has been used by the Corps hierarchy in its efforts to replace performance standards with the NED rule for project performance. However, while the scaling processes could be facilitated by risk assessment and risk management, the P&G does not contain a requirement for such analysis. Introducing this requirement into the P&G is not necessary as long as supplemental guidance calling for risk assessments is promulgated.

In the Corps Hierarchy

The agency's hierarchical management structure, wherein multiple levels of project plan review are conducted, helps explain traditional Corps reliance on uniform standards. A major concern of large organizations with multiple tiers or levels of responsibility is ensuring that decisions at lower levels are consistent with formal policies and the intent of top management. Since Corps projects typically involve the district office, division office, and office of the Chief of Engineers prior to submission through the Secretary of Army to the President for inclusion in a proposed budget, maintenance of control is a significant issue.

The extent of direct hierarchical control varies substantially among organizations, but a relatively high degree of control generally would be expected within military organizations such as the Corps. In a scathing attack on Corps officers, Morgan (1971) notes the tendency toward rigid hierarchical control:

> All of these characteristics of West Point: the sheltered and isolated atmosphere, the rigid regulations, the antiquated curriculum, the method of learning, compulsory obedience without question and the psychological conditioning of hazing commonly have produced graduates who are not independent and creative thinkers. These habits of dictatorship would naturally lead to coercion of subordinates by their superiors.

Even if not the result of the factors suggested by Morgan, "coercion" of subordinates through reliance on standards and conventions to control the design process would likely result because of the relationship between information and decision making. As a decision moves upward in the hierarchy of an organization, the amount of information that can be transmitted to allow review of the decision decreases with each additional level. Underlying assumptions become less clear, uncertainties are forgotten, and the general ability to conduct a rigorous review diminishes (Sowell, 1980; Jackson, 1983; von Miseis, 1983).

This problem increases in proportion to the amount of freedom and creativity exercised by the original decision maker. The greater the creativity incorporated into the decision, the more difficult to articulate the basis for the decision and to transmit necessary information to higher decision-making levels. On the other hand, a design decision relying heavily on standards and conventions is more susceptible to review, a fact that at least partly explains the tendency toward the standards approach evident in hierarchical organizations.

Relaxation of this constraint (standards approach) could require changes in the Corps structure to reduce the number of review points. Increasing design freedom implicit in risk-based decision making requires that more authority to make the final risk versus cost tradeoff be granted to lower units of the organization and to the agency clients. However, review of the quality of the risk assessment will continue. In addition, the Corps has unique problems that must be addressed. But the current situation with its many levels of review and particular review process must be modified. First, the Corps must do a better job of assuring that reviewers of projects are intimately familiar with the risk assessment approach in general and with Corps guidelines in particular. Currently, the Corps has developed a process where those who review project reports are not integral in the development of the procedures under which the analysis is done. This can lead to inconsistency and ambiguity in the study requirements and to confusion among those who must prepare reports.

Concern over Potential Liability

Concern over legal accountability for inadequate project operation or for project failure has a major impact on designers. This concern rises in proportion to the certainty with which liability will follow the occurrence of personal or property injury to others. Whenever the probability of liability is high, adoption of conservative design practices is likely. This influence can affect individual designers as well as the organizations by which they are employed.

Liability is determined by a combination of legislation and the common law of torts. Legislation can be the major factor where a particular activity is covered by a special statute, but tort law is the primary determinant of liability in the absence of such statutes. Whether imposed by statute or by common law, the two principal alternative theories used to determine liability are strict liability and negligence. Strict liability can arise by statutory enactment or common law, while negligence is a common law concept. Whenever the strict liability concept, which is favored by injured parties, is not available in a particular case, the negligence theory generally must be employed.

Negligence theory holds a designer liable for harm resulting from lack of proper care in the design process, where proper care is defined as that expected by a "reasonable person" under the circumstances involved. The applicable standard of care in engineering design is the behavior of an engineer with the education, experience, and judgment expected of a typical member of the engineering profession. This standard is determined on a case-by-case basis and is independent of other standards that may have applied to the event in question.

Under negligence theory, liability does not arise for injuries from design that conforms to appropriate court-determined standards. Strict liability theory, on the other hand, holds a designer accountable for resulting harm without regard to the degree of care employed, thereby eliminating an important defense available in negligence cases. The designer is likely to be liable for any harm resulting from a defective

design except in extraordinary situations such as sabotage of the designed project by a third party.

Injured parties therefore will favor strict liability theory but are limited by restrictions on its acceptance. Strict liability continues to be rejected in the common law of a minority of the states and only applies to certain activities in the states that give acceptance. A traditional area of application is the "ultrahazardous activity," defined to include such activities as use of explosives, keeping of dangerous animals, and storage of dangerous chemicals. More recently, strict liability has received increased acceptance in the product liability area. This application is primarily limited to mass-produced consumer products and generally excludes unique, large-scale projects designed by engineers but constructed and owned by other parties.

Potential for liability depends on the nature of the event resulting in failure or inadequacy of the facility in question. The "act of God" defense arises whenever a natural event such as a flood is of such extraordinary magnitude to defy prediction through reasonable practices.

Potential for liability also varies among different types of defendants. The primary factor here is whether the defendant is a private party (firm or individual) or governmental organization. Sovereign immunity protects governmental defendants from liability in certain situations although the scope of such protection has decreased relative to its previous status.

The following sections explore the following four issues in greater detail: (1) application of strict liability to water project design, (2) application of negligence to water project design, (3) application of the "act of God" defense, and (4) application of the sovereign immunity defense.

Application of Strict Liability to Design of Water Projects Although a minority position, statutes in some states impose strict liability for injury arising from operation of water facilities. For example, a Colorado statutory provision provides that "The owner of a reservoir shall be liable for all damages arising from leakage or overflow of the waters therefrom or floods caused by the breaking of the embankments of such reservoir" (Colo. Rev. Stat. sec. 37-84-104). In the absence of applicable legislation, courts in some states have applied the common law concept of strict liability to water facilities. For example, a Florida court applied strict liability in a 1975 case (Cities Service Co. v. State of Florida, 312 So. 2d 700 (Fla. App. 1975)) involving failure of a phosphate settling pond that killed a large number of fish and caused other damages. But many states refuse to apply strict liability to traditional water projects. Although some of these cases rejecting strict liability are old and therefore weak in terms of precedent value (see, e.g., Lapham v. Curtis, 5 Vt. 371 (1833)), more recent examples also reject strict liability. An example is given by a 1972 New Hampshire decision (Moulton v. Groveland Paper Co., 289 A. 2d (N.H. 1972) in which the court refused to apply the strict liability concept to a situation involving dam failure (see Task Committee on Spillway Design Flood Selection, 1988, Appendix F).

Application of Negligence to Design of Water Projects If circumstances do not support acceptance of strict liability in a case involving injury related to water project design, imposition of liability on the designer generally must be based on proof of negligence. A central issue in proof of negligence is establishing that the applicable standard of care has been violated. Although this burden generally can be expected to fall on the plaintiff alleging negligence, under certain circumstances the burden of proof can be shifted to the allegedly negligent defendant who then must show that negligence has not occurred.

This shifting of the burden of proof is accomplished by adoption of the *res ipsa loquitur* ("the thing speaks for itself") concept. The courts adopt this approach where injury-producing events are of a type that normally do not occur without negligence and are exclusively within the knowledge and control of the defendant.

The *res ipsa loquitur* approach is likely to be adopted where water management facilities fail without apparent cause. Negligence in the form of inadequate design and/or maintenance is likely to be presumed, subject to rebuttal by the defendant (see, e.g., City Water Power Co. v. Fergus Falls, 128 N.W. 817 (Minn. 1910)).

A factor often discussed in negligence cases is the effect of the defendant's compliance with legal standards and requirements applicable to the activity in question. While failure to comply with such requirements facilitates a finding that a defendant has been negligent, compliance generally does not necessarily provide a defense against a charge of negligence. Consideration may be given to legal requirements, but the courts view such requirements as minimum standards and are not precluded from imposing a higher court-determined standard (Task Committee on Spillway Design Flood Selection, 1988). This outcome reflects the fact that law focusing on protection of individuals does not allow the same balancing of risks and benefits with respect to individual victims as is permitted with respect to society as a whole. Thus, aggregate notions of risk acceptability are not applicable to the individual who experiences the losses associated with risk (Jasanoff, 1989).

Application of the "Act of God" Defense to Water Projects. The "act of God" defense is based on the premise that individuals should not be accountable for failures or inadequacies of constructed facilities arising from extraordinary natural events. A key factor in determining applicability of this defense is establishment of the threshold value for an event to be classified as an act of God.

The traditional means of defining an act of God has been based on analysis of actual records of the event in question. An occurrence greater than the greatest recorded occurrence would likely have been considered an act of God (Ryan Gulch Reservoir Co. v. Swartz, 234 p. 1059 (Colo. 1925)).

A second approach adopted by at least one court has applied a significantly more rigorous standard: the probable maximum flood also used by the Corps in designing spillway capacity (Barr v. Game, Fish, and Parks Commission, 497 p. 2d 340 (Colo. et. App. 1972). Since the PMF represents an upper limit on the range of floods possible, its acceptance as the definition of act of God essentially eliminates the act of God defense.

Application of the Sovereign Immunity Defense to Corps Projects A special defense that shields governmental defendants from liability in certain situations is sovereign immunity. This defense, if applicable, does not deal with the merits of the particular case but serves to block legal action due to the governmental nature of the defendant. Evaluation of federal immunity from liability requires consideration of special provisions in federal water management legislation, especially a provision in flood control law creating special immunity aside from the general concept of sovereign immunity.

Sovereign immunity, as it originated in England provided broad protection of the monarchy from lawsuits, but governmental immunity in the United States has been significantly restricted. The primary mechanism of restriction at the federal level is the Federal Tort Claims Act, which abolishes the sovereign immunity defense except as specifically retained. The principal area where immunity is

retained is explained by the following provision setting forth exclusions from the act (28 U.S.C.A. sec. 2680):

> The provisions of this chapter and section 1346(b) of this title shall not apply to "(a) Any claim based upon an act or omission of an employee of the Government, exercising due care, in the execution of a statute or regulation, whether or not such statute or regulation be valid, or based upon the exercise or performance or the failure to exercise or perform a discretionary function or duty on the part of a federal agency or an employee of the Government, whether or not the discretion involved be abused."

The retention of sovereign immunity for discretionary functions has resulted in much attention on the definition and scope of this term. Discretionary functions include policy decisions at top levels of management but also can extend to lower activity levels, including design, construction, operation, and maintenance. But specific actions can be held to be non-discretionary and therefore outside the scope of sovereign immunity, thereby introducing an element of uncertainty. A final determination in a particular situation is a function of the courts (Little, 1976).

Although FTCA authorizes lawsuits against the federal government under certain conditions, it does not provide for application of the strict liability concept but limits actions to negligence proceedings. This restriction offers a degree of protection to federal defendants in situations where sovereign immunity is no longer in effect. The strict liability approach is available against non-federal defendants in some states and offers a reduced burden of proof for the plaintiff in relation to negligence.

Federal immunity from liability for water-project injury also arises from a 1928 provision in flood control legislation stating "No liability of any kind shall attach to or rest upon the United States for any damage from or by floods or floodwaters at any place" (33 U.S.C.A. sec. 702(c)). This provision has been interpreted to provide immunity in a range of cases involving damages from flood protection works and erroneous or misleading weather and flood information. Immunity under this provision does not extend to water management activities undertaken for other purposes such as navigation (Little, 1975).

As a result of the sovereign immunity concept and flood control legislation, Corps exposure to liability is substantially less than that of other water project planners. Therefore, concern for liability should have less impact on Corps water project design than on design in the private sector. But immunity to liability is not complete. Because a court may find certain actions to be non-discretionary, the sovereign immunity concept does not always apply, and immunity under flood control legislation does not apply to projects serving other purposes. Thus, liability cannot be eliminated as an influence on Corps design philosophy.

Several actions can be taken to reduce the effect of liability concerns on design decisions. However, the implementation of such actions must counter general trends in law that promote greater accountability of those responsible for injury. The most direct means of lessening exposure to liability is passage of general legislation granting immunity to parties participating in design. As was discussed previously, such legislation already exists at the federal level and offers a degree of protection to those involved in water project design. Amendments to extend coverage or to reduce uncertainty under existing law could be enacted.

Options for the Corps to modify exposure to liability are limited. Perhaps the best option is to ensure that all affected publics understand the

associated risks and agree to their allocation among the affected parties. An open process of determining acceptable risk is likely to be more defensible than a closed process. However, the courts that must address the merits of lawsuits by individuals who claim injury by a project failure will continue to make ultimate judgments about liability in such cases.

REMOVING THE BARRIERS: THE INFORMED CONSENT APPROACH

At the most fundamental level, a change toward acceptance of risk-based decision making can only come from a focused reconsideration of the ethical relationship of the professional cadre of engineers within the Corps to the public. The issues here are philosophic in tone and extend beyond the special case of water project design to the general relationship of engineers to society. Indeed, the issues extend to government management of risk of all forms and touches directly on the regulation of private activities by all government agencies where the regulated activity is deemed to present health or environmental risk.

Traditional Corps clients have new concerns—those who will pay an increased share of project costs want more influence in planning and design. In some cases, explicit arrangements have been set up to offer Corps clients more access—e.g., is the Waterway Users Board created by the Water Resources Development Act of 1986. More recently, environmental interests have focused upon the role of design standards in creating environmentally disruptive projects. Larger projects that result from conservative standards not only involve greater investment costs but also produce greater environmental impacts. Movement toward risk-based decision making therefore has potential to reduce environmental impact as well as to lower investment in facilities.

What obligation does the Corps have, relative to the public's obligation, for establishing acceptable project performance and reliability? What is the role of economic and environmental cost in answering this question? Addressing these matters of risk assumption and risk sharing as a legal and as a practical matter will be a challenge to both the professional engineer within the Corps and to the public. The questions compel a direct focus on the question of engineering ethics, the perceptions of society about the practice of engineering, and the legal framework surrounding engineering practice, matters which have received increased professional attention in recent years (Broome 1986 and Martin and Schinzinger 1983).

As was noted above, the codes of ethics of most professional engineering societies reflect a basic theme that the engineer will hold paramount the safety of the public, and this view has been translated to the agency image of itself. This ethical imperative has clearly been at work in the water project design area *and* has been an expectation of the public, through the Congress, which benefits from projects. The legal liability rules in existence reinforce this ethical viewpoint.

However, as the previous discussion has illustrated, no project is risk free or, as the quote from David Pye cited in the introduction states, choices and compromises must be made in design. With this in mind, the question facing the design engineer may appear to be the more practical one of designing "what the client wants" and/or can afford, subject to an imprecise mandate to assure public safety. However, this perspective on client service has its own limitations. Adcock (1978) argues that engineers have a higher responsibility than the average citizen because they better understand the limitations and potential consequences of failure of engineered structures. Therefore, too strict an adherence to clients wishes is an abrogation of the ethical responsibility that comes with the engineer's

professional training and may subject the designer or the agency to liability if the project fails to perform.

On the other hand, the position Adcock takes is not incompatible with the argument that engineers balance their professional insights with clients' concerns for such matters as cost. Here, the decision on balancing falls to the professional engineer who is to exercise "engineering judgment." Unfortunately, there are no rules for striking this balance, and if a project failure occurs, public criticism of the engineers and their organization will be severe. Indeed, legal proceedings may ensue. Therefore, it is not surprising that the exercise of engineering judgment has been toward stringent risk aversion.

The only way out of this dilemma, and therefore the only way that the mechanics of risk assessment will be used widely as an aid to decision making, is through an acknowledgment by both the engineer and the public that engineering design is not a certain technical computation (Formaini 1990) and that cost versus risk reduction must always be considered. With this recognition, a new relationship between the engineer and the public can be forged. Broome (1986) in citing the work of Martin and Schinzinger, suggests that moral relationships between engineers and the public should be of the informed-consent variety enjoyed by some physicians and their patients. In this moral model, engineers would acknowledge to their customers that they do not know everything. They would give the public their best estimate of the benefits of their projects (and alternative projects) and the dangers. And, if the public agreed, and the engineers performed honorably and without malpractice, even if they failed, the public would not hold them at fault.

The suggested analogy to the use of informed consent in the doctor/patient relationship is weakened by the fact that engineering decisions affect the public rather than an individual, making complete consent an impossibility. Nevertheless, the informed consent model appears to provide a useful means of moving the Corps toward greater application of risk-based decision making. The objective of Corps risk assessment would be to structure and inform the process by which *an informed-consent decision can be made. In this decision process, the interdependence between cost consciousness of project clients and the ethical relationships between the engineer and society would be simultaneously and openly addressed. However, for this to occur, the Corps must address several issues, some of which may be within the agency's control while some are not.*

A principal focus of the Corps in moving toward the informed consent approach should be on development of clear understandings among project participants on allocation of responsibility for project failure. Just as the new cost sharing rules are creating a new voice for non-federal participants in project planning and design, they also provide the basis for sharing of responsibility. Formal agreements indicating responsibility should be negotiated and established as part of the project record. A logical vehicle for this record is the local cooperative agreement already a part of the project approval process.

Another needed development within the Corps is to change the structure of project review to reduce the number of review points within the planning process. Increasing design freedom is an implicit requirement of risk-based decision making that requires more authority at lower units of the organization to make the final risk versus case tradeoffs. In addition, all reviews must be guided by the same risk management policy and philosophy employed at lower levels of the agency. Without compatibility among the different levels, a move

toward more explicit risk-based decision making will not be possible.

The Corps cannot unilaterally remove barriers arising from broader policies and societal concerns, but it must focus attention on specific issues and advocate change if these barriers are to be addressed. With respect to the concern for liability, specific ambiguities and/or inadequacies in existing immunities must be identified and proposals for change developed. Such proposals cannot be generic in form but must address specific problems. With respect to constraints arising from the expectations of the public, the Corps must support an effort to increase public understanding of probabilities and advocate development of more explicit public policy in favor of risk management. The related constraint arising from the image of the professional engineer must also be addressed in a broad scope. This effort must seek to separate as much as possible technical decision making from social/ethical judgments on risk that currently are obscured within the project design process. Implicit in such action is willingness of engineers to relinquish some of their historical decision prerogatives.

CONCLUSION

The traditional Corps reliance on uniform design standards arises from agency and individual incentives. Pressures to reconsider and modify this approach to decision making are coming from cost and environmental concerns. Explicit risk assessment and risk management would be a major change in the approach the Corps uses to balance the risk of project failure against project cost, but may be a necessary response to this pressure for change.

However, there are barriers to risk assessment and explicit risk management that must be overcome. Barriers to risk assessment can be overcome by actions fully under control of the Corps. However, incentives for strong risk aversion are the inevitable outcome of an imbalance between the potential costs and benefits to the agency and its engineer employees from adoption of a more explicit risk management approach. The possible negative effects of accepting higher risk on the Corps and the individuals involved are substantially greater than potential rewards of achieving lower project costs. This disparity between potential costs and rewards, which appears to affect the performance of governmental officials generally might be especially important in the case of activities with high potential to cause loss of life and extensive property damage. Contributing to this disparity are such factors as public attitudes, engineering professionalism and legal liability.

Adoption of the risk management approach (perhaps via informed consent) implies a willingness to recognize and to perhaps accept greater risk than is typical under the current approach. The fact that movement in this direction confronts serious barriers emphasizes not only the difficulty of change, but the existence of broad support for risk averse decisions. This suggests that substantial change in practice toward explicit risk management would likely require a congressional directive endorsing this approach. Action by Congress in turn must be preceded by general public support. Movement toward explicit risk management therefore is a long-term process. But policy on issues important to public welfare usually evolves slowly. Considering the tendency of the pendulum to swing from one extreme to the other, a cautious approach has merit although it is a source of frustration for those who perceive the need for change.

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APPENDIX C
RISK MANAGEMENT AND COMMUNICATION

RISK MANAGEMENT AND COMMUNICATION

by

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RISK MANAGEMENT AS AN ORGANIZATIONAL OBJECTIVE

What is risk? It is important that we begin with a common definition of risk before discussing the principles of building an effective risk management program (Abkowitz 1994). In this paper, risk is defined as the potential for an incident to cause: (1) human injury, disease, or death resulting from exposure; (2) temporary or permanent damage to property and/or the ecological infrastructure; (3) loss of productivity and quality of life, due to incident-caused delays and evacuations; and (4) loss of revenues and increases in operating cost as reflected in diminished public perception and new regulatory controls.

To control this risk, agencies typically develop a risk management program operated as a process. The program is a commitment by the organization to promote safe practice. The process itself has three basic intentions: (1) to identify hazards and potential exposure; (2) to assess risks of incidents and their resulting consequences; and (3) to reduce risk to the public and the environment. It is this systematic and integrated process that allows one to understand risks, and to define an effective and integrated program to control them.

Why would an organization want to implement a risk management program? There are three main arguments for doing this: (1) a proactive approach leads to improved safety; (2) one can reduce accidents and associated liability, and (3) as a good corporate citizen, the agency becomes a member of the community, demonstrating to the public that they care and can be trusted.

Consider the implications of not performing up to standards; recall the incident involving the Valdez. The direct impact on the shipper was massive: (1) over 2.5 billion dollars in direct expense; (2) 1.1 billion dollars in state and federal settlements; (3) an eroded corporate image; and (4) the cost of over three hundred lawsuits that are still pending. The more far-reaching impact on the industry, however, goes beyond what the shipper itself had to incur. Because of this event, President Bush delayed new offshore drilling to the year 2000, double-hull construction was legislated for all new tankers, and it spawned the Oil Pollution Act of 1990. Even if we were to concentrate on less catastrophic events, one can typically associate acute and extended impacts with each incident.

Litigation associated with these events brings up the important question of how well an agency can defend its practices without a formal risk management program. One can evaluate this in terms of a series of several questions:

- Can your risk management practice be articulated? Do you have a practice in place that you can document and demonstrate that procedures are being followed?

- Can your risk management practice be defended? Are you sufficiently confident that you will be able to convince the judicial process that your agency is handling its activities responsibly?

- Can your risk management program be defended as a best practice? Can you demonstrate that, of all the different methods and practices that exist today, that you have carefully sorted through them and have identified a process that is second to none, in terms of technology, application, and credibility?

Public perception has also been identified as a driving force behind the need to have an effective risk management program. For a variety of reasons, the public feels threatened by potential events they associate with serious consequences. Risk analysts have a tendency to say, "Oh, the public doesn't

really understand the process. We just need to communicate better to convince them we are safe compared to other things that they should be worrying about."

I have an opportunity to teach an environmental risk management class at Vanderbilt University. Students taking this class rarely have much background in environmental risk management before they begin this course. In a paper submitted at the beginning of the semester, one student said the following (Robinson 1994): "What the public perceives as the risk, whether true or not, is the risk that we have to manage." If you take a moment to reflect on this statement, you will begin to understand that no matter how well risk managers believe they are controlling risk, if it does not gain the public trust, we are not managing the right program.

Unfortunately, the management culture in place in most agencies today creates a reactive rather than a proactive attitude, and this severely hampers the success of implementing a program in risk management. In addition, the problem is further compounded by the fact that many different stakeholders within the organization have varying definitions of risk. For example, the quality assurance department views risk as the *likelihood of a defect*. The safety department might see risk as a *hazard*. Loss financing might view risk as *insolvency*. There are many other areas within corporations that also have different perceptions. The challenge is how to define risk in terms that stakeholders can understand, communicate and support.

This apparent conflict within an organization suggests that risk management needs to become a vital part of strategic planning. Arguably, risk management is a key component of strategic planning and total quality management initiatives throughout the organization.

DEVELOPING A RISK MANAGEMENT PROCESS

The risk management process is designed to achieve five basic objectives: (1) identify sources and undesired outcomes of risk; (2) establish risk related goals; (3) utilize a total systems approach; (4) apply appropriate risk analysis tools; and (5) implement the process and manage risk throughout the process lifetime (Abkowitz 1994).

Figure C-1 presents a flow chart of the individual steps, which when pulled together, represent a comprehensive risk management program. The process begins with establishing a culture within the organization. This culture, as mentioned earlier, is needed to gain the support of upper management and the cooperation of stakeholders in the organization. With that support, one can proceed with creating an organizational risk management structure. It is this structure that becomes the framework for designing, implementing and monitoring the risk management program. Individuals that participate in this structure must reach a consensus on the procedures, guidelines, and communication processes needed to ensure that all elements of the program succeed. This planning process will introduce several recommended initiatives. It is important to recognize up front that considerable resources may be needed to perform these tasks. Therefore, identifying resource requirements is a very important activity.

It is at this point that the process enters a formal risk analysis (assessment) phase. The risk assessment process (RAP) involves three steps, beginning with establishing assessment priorities. These are the agency activities that require the greatest attention from the risk management program. Once these activities have been identified, risk assessments can be performed at various levels of detail, depending upon the complexity of the problem and the information available. Finally, after

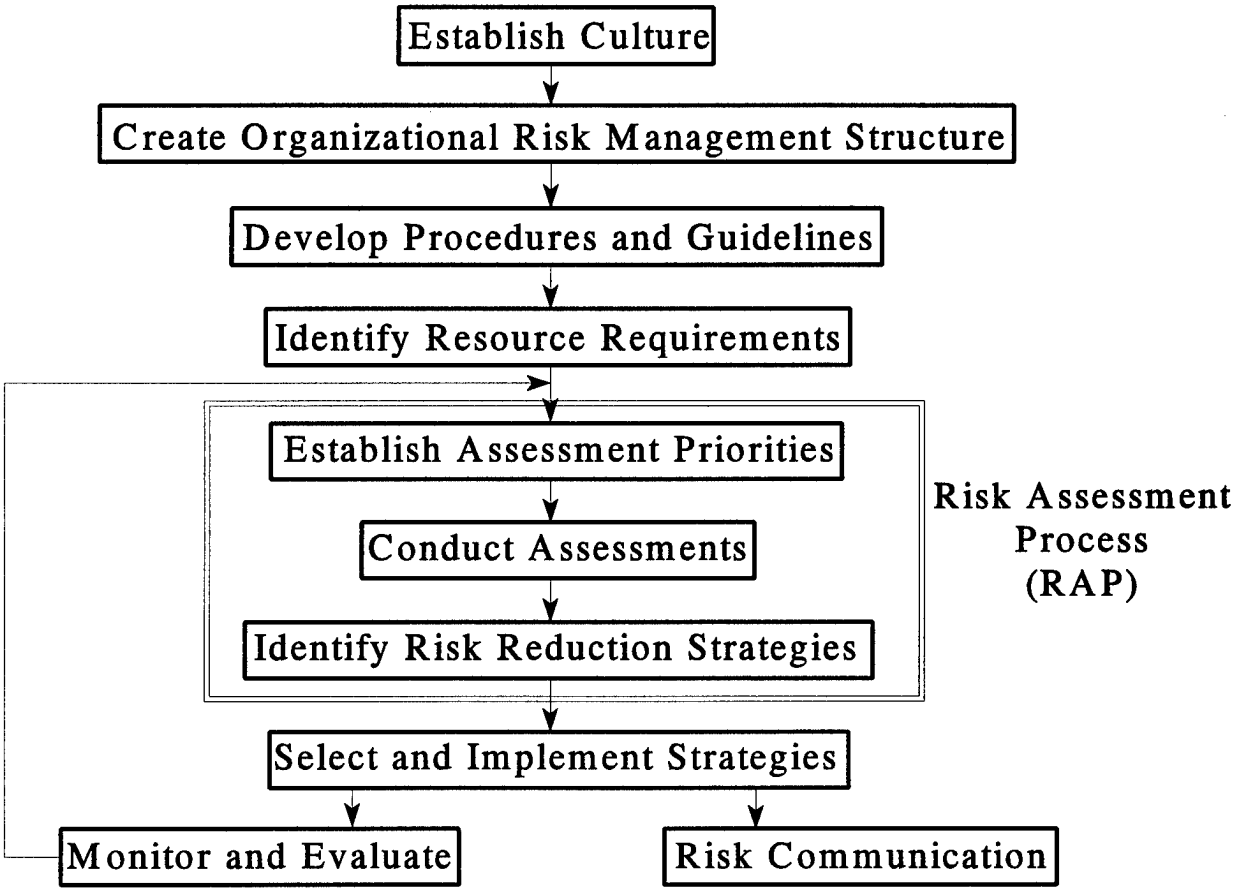

FIGURE C-1
THE TRANSPORTATION RISK MANAGEMENT PROCESS

honing in on specific problem areas, risk reduction strategies can be identified where management controls are likely to be effective in reducing current risks.

Those strategies that appear to be most promising from the standpoint of cost-effectiveness and the feasibility of implementation within the organization, become the strategies that are selected and implemented. At this point, the process enters into a monitoring and evaluation phase, where one reviews whether the strategies that have been selected are succeeding within the organization. Concurrent with this is a marketing and communication effort. This includes informing internal stakeholders who need to cooperate with or would benefit from the risk reduction effort, as well as informing the external public as to what you are doing, why, and how it will improve their quality of life.

Process Implementation and Evaluation

The distinguishing factor in establishing a healthy risk management culture is the attitude of upper management (Foshee 1994). A proactive attitude is essential. Organizations that have been successful in implementing a healthy culture take the following approach. They say: "We already have a good approach to safety, however, we need to enhance, provide more consistency, and implement this comprehensive approach more widely throughout the organization. Let's appoint a champion (risk management coordinator) to implement this program and let's give them the resources, time and effort that they need." Selecting an effective risk management coordinator is a key management decision. This person needs to be an organizer and a cheerleader.

The risk management coordinator has the following responsibilities. He or she should lead the risk management team, and coordinate all the elements, activities and implementation efforts within the program. They should believe in what they are doing and make it contagious. They must identify the best people and get them on board; not the easiest ones to find, but the best. And, finally, they should be inclusive with the process; inclusive internally with all the stakeholders that are a part of the process and inclusive externally, getting the public involved and invested in what the agency is doing.

The risk management coordinator should organize an effort that is carefully planned and ambitious in nature. It should be driven by three principal objectives: (1) to be resource smart by integrating risk management into a single, systematic process; (2) to be in compliance with codes and regulations as a primary objective; and, (3) to design the process to meet the most stringent of similar requirements from all relevant codes and regulations. By addressing the most stringent requirements, the others are satisfied implicitly.

In addition to the risk management coordinator, the team should be assembled by selecting key stakeholders. When the team is initially assembled, it is important for everyone to introduce themselves and to recognize that, although they have vastly different responsibilities, they share a number of common threads that are important to the business. How often in the past have you attended meetings where strategic planning, purchasing, engineering, and legal people are all sitting in the same room conversing on the same project?

Once assembled, the team has several initial tasks and other more ongoing tasks. The initial tasks begin with understanding the new program objectives and the goals of the group. Then, one should review existing efforts and match those against the objectives of the new program to determine their responsiveness and what changes are appropriate. This is followed by development of a process and formal documentation of a number of

the steps that the team will consider. These include: (1) the purpose and scope of the effort, (2) goals and objectives, (3) participants and their roles, (4) operating procedures and guidelines, (5) operations under evaluation, (6) inventory of hazards under consideration, (7) risk review process that will be implemented, (8) risk acceptance criteria, (9) approach to management control strategy development and implementation, (10) plan to communicate risks internally and externally, and (11) process for monitoring and evaluating implemented changes.

Successful teams establish workable procedures and guidelines. They agree to meet frequently during the organization effort. They are pragmatic about establishing goals of practice and place by an agreed upon time. Recognizing that this can only be accomplished by dividing out tasks, they form breakout teams to tackle smaller problem areas. Gradually, as work progresses and the comfort level increases, this effort evolves to a point where the team really serves as a steering committee, meeting periodically to review and coordinate breakout team efforts. As the initial tasks proceed, the situation is under control and more people are involved in the process, the steering committee can revert to examining ongoing tasks. In this capacity, the steering committee: (1) provides leadership to the process implementation effort, (2) lobbies for and provides necessary resources to implement the program successfully, and (3) keeps senior management apprised of the progress that is being made.

If there is a pitfall in this process, it is in the under-estimation of the resource investment required to implement the program effectively—people, time and dollars. One must think about each of these components carefully in building a plan for investment. In the area of personnel and time commitment, one should consider the level of activity invested in breakout team participation, the frequency with which steering committee members meet and perform research, and the level of communication that involves senior management.

Hard dollar financial investment in this program comes in many forms: (1) training, (2) travel, (3) use of outside consultants, (4) acquisition of data and tools, and (5) over the long-term, the capital and operational investment in risk reduction strategies.

Risk management coordinators have identified two key elements as initial challenges. First, there is the difficulty in visualizing how to successfully integrate all of the program elements and stakeholders. Second, is the problem of informing stakeholders as to the importance of this mission throughout the organization. The ongoing problem has been commitment of resources. This includes resources for fundamental initiatives, those needed because the process has defined several new or expanded activities, audits and follow-up work, where appropriate, and investment in education and training.

RISK COMMUNICATION

Part of defining an effective risk communication process is understanding the relationship between risk communication and risk assessment (Abkowitz 1994). Whereas risk assessment is a technical process where one identifies high hazard movements, performs risk analyses and develops risk reduction strategies, risk communication focuses on the human elements of the process, namely, understanding risk behavior and building trust and credibility.

The key step to an effective risk communication process is promoting a dialogue between all key members, both internally and externally. The value of an internal dialogue is that it allows one to inform agency stakeholders as to the process which has been structured, the results of the effort, any new risk reduction initiatives and their justification,

implications to different departments and individual decision-makers, and the level of communication and cooperation requested in order for the initiative to be successful. Outside interest is important to this process because of the need to provide public information, to create an opportunity for feedback, to offer assurances that your organization cares, to seek outside cooperation and communication as a partner, and finally, to develop an image of good corporate citizenship.

There are advantages to thinking of internal stakeholders and outside interests as one large public. In fact, there are many publics. Figure C-2 lists a number of the publics that we feel are critical to the success of a risk communication program. It goes well beyond the typical definition of the public as being the citizens. The media, for example, is a separate public, as are elected officials, emergency responders industry groups, regulators as well as environmentalists. Therefore, one needs to develop a program that is comprehensive in nature and responsive to this public.

Most people, when presented with risks, categorize those risks according to the nature in which they can address them (University of New Mexico 1993). Do I understand the process involved in the activity or is there uncertainty associated with it? Is this being imposed on me, or is it a voluntary action that I am taking? How controllable is the activity from the standpoint of management reducing or alleviating the risk? Are the consequences potentially catastrophic or are they benign? Is this a man-made activity or a natural phenomenon? Are the benefits and risks unfairly shared or are they distributed equitably across society? For some reason, even when we take these issues into consideration, there seems to be a heightened perception today about safety. There are a number of different activities in our everyday life that is allowing this to happen. First, people are aware of recent catastrophic events that have taken place over the last decade. In addition, we are well aware of the volume of litigation and often conflicting testimony coming from expert witnesses. Furthermore, there is a general perception that technology should be able to devise failsafe systems for just about everything. There has also been a "social amplification" of risks to advance media and political motives. And, finally, there is a tendency for all of us to become more cautious as we become a wealthier society. As noted by Aaron Wildavsky (University of New Mexico 1993): "How extraordinary, that the richest, longest-lived, best protected, most resourceful civilization, with the highest degree of insight into its own technology, is on its way to becoming the most frightened."

This problem has also been exacerbated by too much credit given to risk management as a science. In truth, risk management is in its infancy as a formal discipline. There is much we need to learn and improve: (1) the validity of the data that we use to perform risk assessments, (2) the uncertainty of the predictions of the overall risks, and (3) the relevance of how we apply different methods to different problems. No matter how much this improves, art will always be a component of risk management.

Disagreements among risk analysts and the public have been fostered by differing viewpoints (Slovic et al 1991). Risk analysis tends to address a problem that is narrow in scope, with an approach to solving the problem that is quite detailed, and where the methods are quantitative. As a result, the scientific approach to risk management has always been strong on details, but weak on the big picture. In contrast, the public views this problem as broad in scope, as part of an everyday life of different decisions which involve risks and economic expenditure. This complex web of issues and emotions is approached qualitatively. Therefore, public opinion is driven by a process that is weak in detail, but strong in the big picture. If these two groups would admit to their strengths and weaknesses, they might understand that working together is the preferred approach.

Risk Communication: There Are Many Publics

- ☐ Internal stakeholders
- ☐ Industry
  - Shippers
  - Carriers
- ☐ Regulators
  - Federal
  - State
  - Local
- ☐ Emergency
- ☐ Environmental groups
- ☐ Elected officials
- ☐ Media
- ☐ Citizens
- ☐

FIGURE C-2
RISK COMMUNICATION

When risk communication fails, it begins with a misunderstanding that leads to conflict. Once the conflict is in place, generally inaccurate information is provided by both sides, leading to greater hostility and eventually gridlock. By working together, a two-way dialogue could be promoted where analysts would communicate with the public and vice-versa. Ultimately, the goal of this dialogue is building trust. Trust is the foundation of effective risk communication. Can I believe what you are telling me?

Trust is only gained if one can build credibility. This is done by being knowledgeable, competent, honest, frank, fair and consistent. Trusting someone does not obligate you to like or even agree with them, but it should allow you to respect their opinion. This is the basis for constructive exchange. In building credibility, a number of proactive actions should be taken:

- Treat the public as a customer, understand their needs and how best to establish a dialogue.
- Be honest, frank and open.
- Listen to their concerns.
- Accept and involve the public as legitimate partners in your process. This is both a communication strategy and a risk reduction strategy.
- Plan carefully and evaluate your efforts.
- Speak clearly and with compassion.
- Coordinate and collaborate with other credible sources.
- Meet the needs of the media.

It has been easy to blame risk communication failures on the media. However, by understanding the media and working with them constructively, some type of partnership can be formed. One should recognize that the media has considerable public influence; therefore, media relations should be an ongoing part of every organization's strategic plan. Plan to generate regular press releases to the media in order to provide background information with which you can communicate in the event of an incident. And, finally, make personnel available on an ongoing basis, in non-emergency situations. This will build credibility with the media. With this approach, when an emergency occurs, you will not be seeing them for the first time and they will know that your organization genuinely cares.

There are also some real-time, risk communication strategies that would be helpful for managing an incident when one occurs. Realize that potential problems will be discovered sooner or later--sooner is definitely better. Secondly, assume responsibility for mistakes which have been made. Finally, move quickly to fix problems when they arise.

Now we can apply these principles to the overall program management plan where risk communication connects with risk analysis (Sloway 1992). A proper linkage must be established that allows risk analysis results to be communicated in the proper context to the publics that are being served. This can be done effectively if it is recognized that people are more concerned with trust rather than quantitative measurement.

Secondly, quantified risks or mortality statistics are not likely to be easily understood by *any* public. One must be able to define these consequences in plain language. This suggests that perhaps risk communication guidelines need to be considered in the overall risk management program even before the assessment process begins.

It might be helpful to establish these guidelines by having an outline of the way in which one would present information that comes from the risk analysis

process. One approach would be to communicate risk in three stages: (1) how can an accident happen?, (2) how often could that scenario occur?, and (3) how bad could the consequences be? It may also be helpful to communicate risk in terms of relative risks that the public understands from their everyday lives, such as the risk of getting hit by a car, or the risk of getting hit by lightning. And, finally, graphical display of the results is very important in helping the public visualize the information that is being provided.

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APPENDIX D
RISK ANALYSIS, RISK COMMUNICATION, AND RISKY DECISION MAKING

RISK ANALYSIS, RISK COMMUNICATION, AND RISKY DECISION MAKING

by

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* The comments of James R. Bettman on an earlier draft of this paper are greatly appreciated.

INTRODUCTION

Complexity, uncertainty, and risk define the business environment of the 1990s. As a result, businesses are increasingly using analytical tools to help understand the uncertainties and risks they face. Risk analysis is one such set of tools. Likewise, the use of risk-based decision-making tools has increased in the public sector. For example, the Corps of Engineers is encouraging the use of risk analysis techniques in evaluating its proposed investments. The hope is that the use of such risk-based methods will enhance both the decisions made by the Corps of Engineers and by its customers (partners).

The purpose of this paper is twofold: First, the paper briefly describes my experiences in communicating the techniques of risk-based decision making to executives from both the private and public sectors. The hope is that insights from my experiences in teaching risk analysis to business executives will be helpful in the effort to promote the use of risk-based decision making within the Corps. Second, a few issues in the communication of risk information are discussed. The focus is on what we know about risk communication and decision making as it relates to the problem of conveying the results of a risk analysis to decision makers, both within and outside the Corps of Engineers. More complete discussions of issues related to risk communication can be found in the National Research Council report on improving risk communication (Ahearne et al., 1989).

RISK ANALYSIS

As a method for helping decision makers cope with an uncertain world, the technique of risk analysis is an old one. As long ago as 1964, David Hertz wrote an article entitled "Risk analysis in capital investment" that outlined how the uncertainties surrounding each of the key elements of a decision could be determined, and how the combined effects of those uncertainties on outcomes could be estimated using Monte-Carlo simulation. That article has become a classic in the management literature (Hertz, 1979).

Today, the tools of risk analysis are used to help evaluate, analyze, and quantify many major business decisions. As an example, risk analysis was used by Merck to help evaluate the proposed $6.6 billion acquisition of Medco, the mail-order pharmacy company. In the words of Judy Lewent, chief financial officer of Merck: "Monte Carlo techniques are a very, very powerful tool to get a more intelligent look at a range of outcomes. It's almost never useful in this kind of environment to build a single bullet forecast" (quoted in "A new tool to help managers," Fortune, May 30, 1994). Merck feels that a risk analysis, with its range of outcomes, both stimulates discussion and facilitates decision making (Nichols, 1994).

Interestingly, the current use of risk and decision analysis techniques by companies like Merck represents somewhat of a revival of the techniques. As discussed in a recent article on the application of decision and risk analysis at DuPont (Krumm & Rolle, 1992), efforts to use decision analysis in the early 70s were not very successful. However, since the mid-to-late 80s, much has changed at Du Pont and elsewhere. First, the need to be able to make decisions in the face of a faster-moving, more uncertain environment is now widely recognized. Second, the PC revolution and new user-friendly software have made the effort and expense of doing risk analysis much, much less. An example of such commercially available software is the program called *@RISK* (Palisade Corporation). One important feature of the new risk analysis software is that it works with spreadsheets like Lotus 1-2-3 or Excel. Managers are generally familiar with spread sheets. Risk analysis then becomes a natural

addition, "Add-in", to a tool already used by managers. Third, the concepts and techniques of risk analysis are now taught to the marketing, manufacturing, and financial people who make up business teams, not just to operations research professionals. Consequently, as noted above, the tools of risk analysis can be used to stimulate discussion among people representing a variety of perspectives. All of these factors have contributed to the increased acceptance and use of risk analysis techniques by management. In the next section of this paper, I will outline how I teach the techniques of risk analysis to general managers representing a variety of private and public sector organizations.

EXECUTIVE EDUCATION IN RISK ANALYSIS

As a vehicle for talking about risk analysis I have used a case called "Graycap", a copy of which is attached as appendix A. The problem in the Graycap case is deciding whether or not to go ahead with a new product introduction. It is a case that has served well to motivate and introduce the concepts and tools of risk analysis. Like many of the decisions faced by the Corps of Engineers, the Graycap case involves multiple sources of uncertainty that need to be evaluated in order to get a picture of the overall risk associated with different decision options.

As is true for most educational efforts, the first part of my attempts to communicate risk analysis to executives is concerned with motivating the problem. In that regard, I try to make three points. First, the fact that the case involves substantial uncertainties needs to be made very explicit. This process is helped by having the executives perform some simple sensitivity and scenario analyses. The idea is to drive home the point that in the face of multiple uncertainties, such as customer demand and competitor response, one must think in terms of a range of possible outcomes, not in terms of a single most likely outcome.

Second, I demonstrate the point that without some structured form of thinking about uncertainties and risk people tend to get lost. This point is illustrated by showing how different teams of managers often produce very different ideas about worst-case and best-case scenarios for a problem. The reason for the differences is that the worst-case and best-case are typically defined in a verbal fashion. Consequently, the different groups of managers defined the terms, and thus the ranges of uncertainties, differently. This point is also reinforced by showing how much variability across individuals there is in interpreting verbal expressions of uncertainty such as a "fair chance" of success. Thus, the quantification of uncertainty and risk can help decision making by simply helping the communication among people involved in the decision. Increasingly, the use of a computer-based decision support system is proving valuable in aiding group processes.

The third point I try to make in order to motivate the technique of risk analysis is that uncertainty is not the same as ignorance. In other words, there is an important state of knowledge that lies between "I know something for sure" and "have no idea about what might happen." This point is crucial. The assessment of uncertain knowledge needs to be seen as a "value added" process and not as an attempt to evade responsibility for an answer. Saying that some value is certain when it is uncertain should be viewed as much an evasion of responsibility as saying that one has no idea about what might happen with an uncertain variable. Using the Graycap case as an example, one should be just as unhappy with an oversimplified response that market share will be 70%, as the statement that market share could be anything from 0% to 100%. Another way of saying this is that one should distinguish between (a) a point estimate for a variable like expected market share, (b) a range of

possible values for the same variable, e.g., worst and best possible values, and (3) a distribution of values which reflects one's knowledge about more and less likely values.

Having motivated the need for risk analysis, the next step is to outline the key stages of a risk analysis process. In that regard, I use a simple four stage model. The first stage is to structure the problem by identifying the key uncertainties in the decision problem. Key uncertainties can be defined in terms of two attributes of a variable: (1) how much it matters (impact) if your estimate is wrong, and (2) how much knowledge\control you have regarding the variable. A useful device for communicating the role of the uncertainties in a problem is an influence diagram. See Figure 1 for an example of a simple influence diagram developed for the Graycap case.

The second stage of a risk analysis is to assess the knowledge about the key uncertainties. I stress that this assessment (quantification) of uncertain knowledge is the key part of the risk analysis process. Thus, I spend a substantial amount of time on assessing subjective uncertainties about such variables as market share and competitor response. I also spend time discussing "traps" in intuitive judgment, such as anchoring effects and overconfidence, that might interfere with the assessment of knowledge (see Russo & Schoemaker, 1989). Finally, simple tools for improving the quality of subjective forecasts are presented. An example of an assessed subjective probability distribution for the key uncertainty of initial market share in the Graycap case is given in Figure 2.

It is important to make two points here: (1) differences in subjective assessments across individuals are OK, and (2) one can use the tools of risk analysis to explore when differences in opinion matter for a decision and when they do not. One can easily use risk analysis techniques to perform sensitivity tests on differences in opinions. In

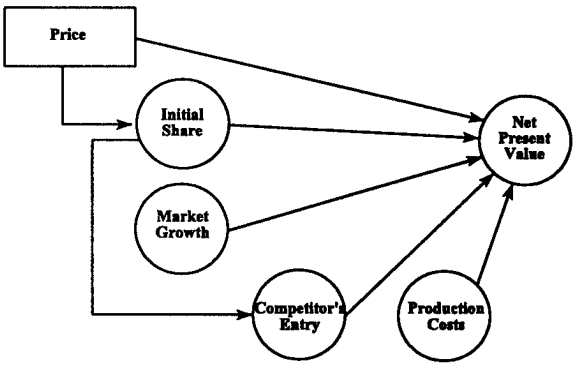


FIGURE D-1
INFLUENCE DIAGRAM FOR GRAYCAP CASE

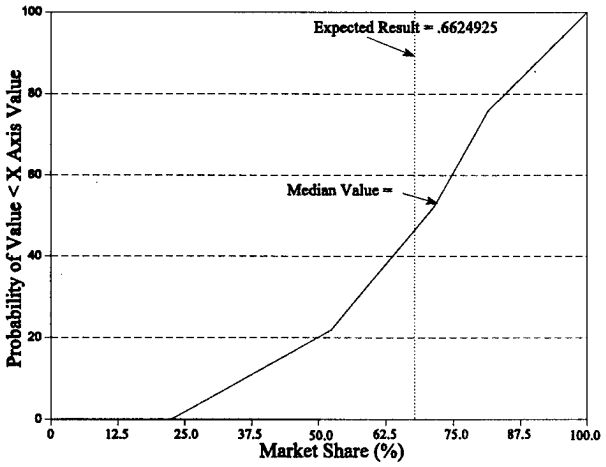


FIGURE D-2
ASSESSED DISTRIBUTION FOR INITIAL MARKET SHARE: GRAYCAP CASE

general, the ease of sensitivity testing with computer-based tools like *@RISK* is very important in generating acceptance of risk analysis.

The third stage of the risk analysis process is the use of Monte Carlo simulation tools like *@RISK* to combine uncertain knowledge about multiple variables. This is a fairly straightforward exercise. Figures 3-5 are sample outputs from a Monte Carlo simulation using *@RISK* for the Graycap case. Figure 3 is a probability density graph of possible NPV outcomes for the option of going ahead with the new product launch. Figure 4 is a cumulative probability distribution of the same NPV outcomes. Figure 5 is a graph showing the relative impact on NPV of varying each of the key uncertainties in the case while holding the values of the other uncertainties constant. Figure 5 represents a "tornado diagram" or sensitivity chart.

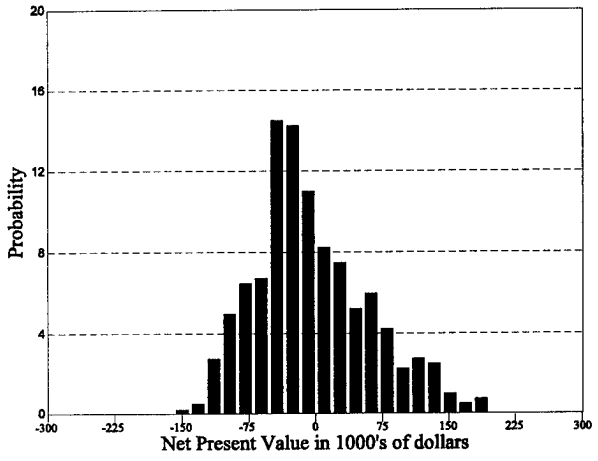


FIGURE D-3
GRAYCAP: DISTRIBUTION OF NET PRESENT VALUE

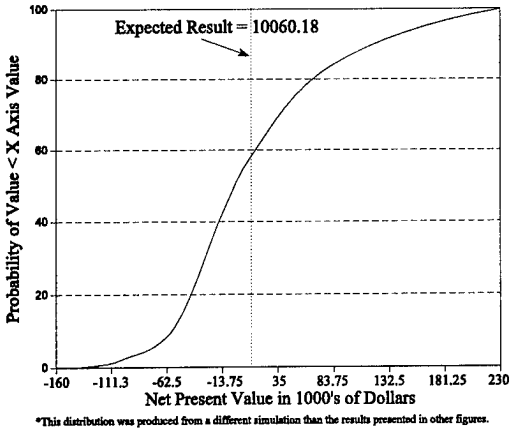
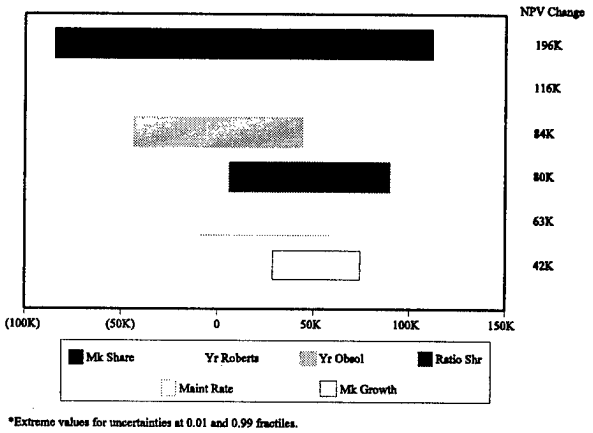


FIGURE D-4
GRAYCAP: CUMULATIVE DISTRIBUTION OF NET PRESENT VALUE*

The fourth, and last, stage in the risk analysis process is the use of the results of the simulation as one input to the decision making process. The results of a risk analysis should be framed as only one input into the decision making process, not as the final decision. Different individuals might agree on the results of a risk analysis but might come to different conclusions about the best course of action to take. Those different conclusions can reflect very reasonable differences in risk attitudes.

Related to the last point is the need to communicate multiple statistics from a risk analysis to the decision makers. Clearly, communicating only the expected value of a measure (e.g., NPV) from a risk analysis is not sufficient. One also needs to communicate other statistics, such as the range of possible outcomes, the probabilities of reaching



*Extreme values for uncertainties at 0.01 and 0.99 fractiles.

FIGURE D-5
SENSITIVITY CHART FOR GRAYCAP UNCERTAINTIES*

certain target outcomes, etc. More generally, this last stage of the risk analysis process relates to the twin issues of risk communication and how people make risky decisions.

RISK COMMUNICATION AND RISKY DECISION MAKING

How do people use the information they are provided about the probabilities and sizes of possible gains and losses to choose among courses of action? What are the better (poorer) ways to communicate probability and outcome information? The first question, dealing with how decisions are made, has been the subject of decades of research by psychologists, economists, and others concerned with risky decision behavior. One obvious conclusion from that research is that people often have difficulty thinking about and resolving the risk/benefit conflicts apparent even in simple gambles. As a consequence, people often use risk information in a variety of heuristic ways to simplify the decision making process. In this section of the paper I will briefly review some of the current research results from the psychology of risky decision making and discuss the implications of those results for the communication of risk information. A theme of that research is the highly selective use of probability and outcome information.

Aspiration Levels, Targets and Reference Values

As long ago as 1955, Herbert Simon argued that one way that decision makers would try to simplify difficult decisions is through the use of aspiration levels, targets, or reference points (Simon, 1955). The idea was that it was simpler to think of outcomes as being either above (+1) or below (0) some target value than to worry about how relatively attractive a particular outcome was. Many experimental studies of risky choice behavior since 1955 have demonstrated the important role an aspiration level or target value plays in determining how people respond to decision problems (see Payne, Bettman, & Johnson, 1992). On a more theoretical level, the significance of the aspiration level concept has been emphasized by the Kahneman and Tversky (1979; Tversky & Kahneman, 1992) in the development of prospect theory. Aspiration level concepts also play a major role in other recent descriptive theories of risky decision making, e.g., Lopes (1987) and March and Shapira (1987; 1992).

Prospect Theory

Currently, prospect theory is the major alternative to the expected utility model as a description of decision making under risk. According to prospect theory, risky decision making is a two-phase process. The first phase involves editing the given decision problem into a simpler representation in order to make the evaluation of gambles and choices easier for the decision maker. A key operation in the editing phase is the decision maker's coding of each outcome of a gamble as being either a gain or a loss, with a gain or loss defined by the relationship of the outcome to a reference point or level of aspiration.[3] The second phase in risky decision making involves assigning an overall value to each edited gamble and choosing the gamble with the greatest value. The overall value assigned to each gamble is assumed to be a function of the values assessed for each coded outcome, denoted v(x), multiplied by an associated decision weight, denoted w(p), which reflects the impact of the probability of the outcome on the desirability of the gamble. Note that the assignment of a v(x) to a particular outcome x will be more cognitively demanding than the simple, 0-1 valuation proposed by Simon (1955). Decision weights are normalized so that w(0) = 0, and w(1) = 1. However, it is important to be clear that decision weights are not subjective probabilities. A basic idea of prospect theory is that preferences among risky prospects will be nonlinear in probabilities.

The value function of prospect theory, v(·), exhibits diminishing sensitivity from the reference point and a greater sensitivity for losses as compared to equivalent gains. Often the status quo serves as the reference point in the evaluation of values. See Figure 6 for a general form of the value function.

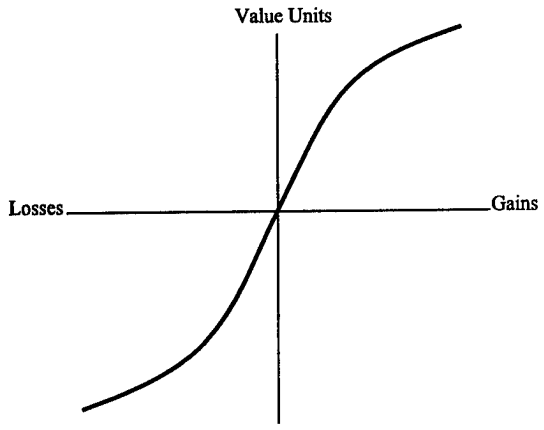


FIGURE D-6
HYPOTHETICAL VALUE FUNCTION OF PROSPECT THEORY

Similarly, the weighting function of prospect theory, w(·), is also assumed to exhibit diminishing sensitivity from a reference point or points. Further, Tversky and Kahneman argue that there are two natural reference points, certainty and impossibility, in the assessment of decision weights. As a consequence, they argue that increasing the probability of an outcome by 0.1 has more impact when it changes the probability of that outcome from 0.9 to 1 or from 0 to 0.1 than when it changes the probability from 0.3 to 0.4 or from 0.6 to 0.7. Kahnenman and Tversky generally hypothesize that people tend to overweight small probability outcomes and underweight moderate to large probability outcomes.

While prospect theory makes some general predictions about the shape of the weighting function, Tversky and Kahneman (1992) do acknowledge that the function is not well-behaved

near the endpoints. In their words, "very small probabilities can be greatly overweighted or neglected altogether" (p. 303).

McClelland, Schulze, and Coursey (1993) recently provided some experimental results consistent with a bimodal response to small probability events. In their experiments subjects were asked to bid for insurance to prevent a fixed loss of either $4 or $40 at probabilities ranging from 0.01 to 0.9. McClelland et al. (1993) report that for the problems involving the lowest probability of 0.01, subjects either bid $0 or much more than the expected value of the gamble. This bimodal response distribution persisted over multiple decisions. McClelland et al. suggests that people appear either to dismiss the risks or to worry too much about them. See Smith and Desvouges (1987) for other data suggesting a bimodal response to low probability hazardous events.

One speculation is that the communication of the results of a risk analysis may show similar individual differences in response. For some people the extremes of the range of outcomes may be given a lot of attention. That is, the worst-case and/or best-case outcomes may be overemphasized.[4] On the other hand, it may be that some people will dismiss risks that are very small even though the potential consequences may be very large. One option for risk communication is to only report the outputs from a risk analysis that exceed a certain specified level of probability, e.g., 0.01. Another option is to only report outcomes in terms of target values with their associated probabilities, e.g., the probability of a loss greater than $90,000 in the Graycap case is less than 0.1.

Security-Potential/Aspiration (SP/A) Theory

Lopes (1987) has developed another descriptive theory of risky decision making called SP/A Theory. Like most researchers, Lopes sees risky decision making as a conflict between the desire to avoid loss and the desire to maximize gain. Lopes calls the desire to avoid loss "security-mindedness" and a focus on what one might gain "potential-mindedness." Extreme forms of either "security-mindedness" or "potential-mindedness" involve giving all the decision weight to the worst outcome or best outcome, respectively. More generally, Lopes sees most people exhibiting a mixed pattern of being security-minded for low outcomes (i.e., proportionally more attention is devoted to worse outcomes than to moderate outcomes) but with some overweighting (extra attention) given to the very best outcomes.

Evidence in support of SP/A theory, and for individual differences in the tradeoff between avoiding bad outcomes (security) and seeking good outcomes (potential), can be found in Schneider and Lopes (1986). That study is also interesting because it is one of the few experimental studies of risky decision behavior that uses complex multioutcome gambles as stimuli. The use of gambles that have many possible outcomes is likely to better represent the results of a risk analysis project than the simple two outcome gambles that have been the focus of most research on decision making under risk.

Variable Reference Levels

March and Shapira (1987; 1992; see also Crum, Laughhunn, and Payne, 1981) have argued for two focal values in making risky decisions. The first focal value is the breakeven (gain vs. loss) target value. This target value is similar to that of prospect theory. The second focal value is a survival or ruinous loss level. These two reference values partition the outcomes into three ranges: gain, loss, and ruin. There is evidence to suggest that when a ruinous loss is possible, people tend to use a more lexicographic choice process[5] that results in a risky option with a ruinous loss being rejected

without any possibility of a tradeoff with desirable characteristics. March and Shapira have argued that the focus of attention on the breakeven versus ruinous or survival level will depend on current performance as well as more momentary factors that drive attention, such as agenda effects.

In general, the results of Tversky and Kahneman's investigation of decision weights, Lopes' notions of security- and potential-mindedness, and the ideas of March and Shapira suggest that people will overemphasize the extremes of the distribution of possible outcomes generated from a risk analysis. In particular, ruinous outcomes will be given great weight. Further, the Corps of Engineers needs to be aware of the possible strong differences among people in how they respond to the extremes of the range of values generated by a risk analysis.

Graphical Communication

Computer-based tools like *@RISK* have the potential to produce different forms of graphical outputs. In addition, the numerical results of a risk analysis can easily be imported into a variety of graphing programs. One issue raised by research on risky decision behavior is the use of different types of graphs to convey the results of a risk analysis.

Which type of graphical representation is best at communicating uncertainty and risk information? As noted by Morgan and Henrion (1990), there has been remarkably little research on the use of graphics to communicate uncertain information. Nonetheless, what little data that do exist suggest several conclusions: First, there is the obvious point that no one method for presenting a probability distribution works equally well in communicating all aspects of a probability distribution. For example, a graphical display showing a probability density function, e.g., Figure 3, is good at conveying the ranges that a variable might assume. It also clearly presents the mode(s) of the probability distribution. On the other hand, a graphical representation of the cumulative density function, e.g., Figure 4, makes it easier for people to answer questions about the probability that a value above (below) a specified target will be reached. The cumulative representation also makes it easier to determine if one distribution stochastically dominates another. (A feature in *@RISK* makes this task straightforward.)

Given the research on risky decision behavior discussed above, variations on the probability density representation likely will prove most acceptable to decision makers. The reason is that people seem to pay relatively more attention to the extremes of the distribution of possible outcomes. Of course, this increased attention could also be viewed as a disadvantage of the probability density format. Morgan and Henrion (1990), on the other hand, suggest that the best strategy for communicating uncertainty with graphs is to provide a display in which a cumulative density function and a probability density function are plotted directly above each other with the same horizontal axis. See Figure 7 for an example of such a display. They also recommend that the mean of the distribution be clearly indicated on both curves.

Target Effects in Risk Communication

As noted earlier, a key feature of prospect theory and other models of risky choice behavior is the idea of a reference level used to evaluate outcomes as gains or losses. Recently, Smith, Desvouges, and Payne (1993) have shown that whether an explicit reference or target value is present or absent in a risk communication effort can impact the actual efforts people report taking to mitigate against a risk such as radon in their homes. As part of a larger study on risk communication, Smith, et al. (1993)

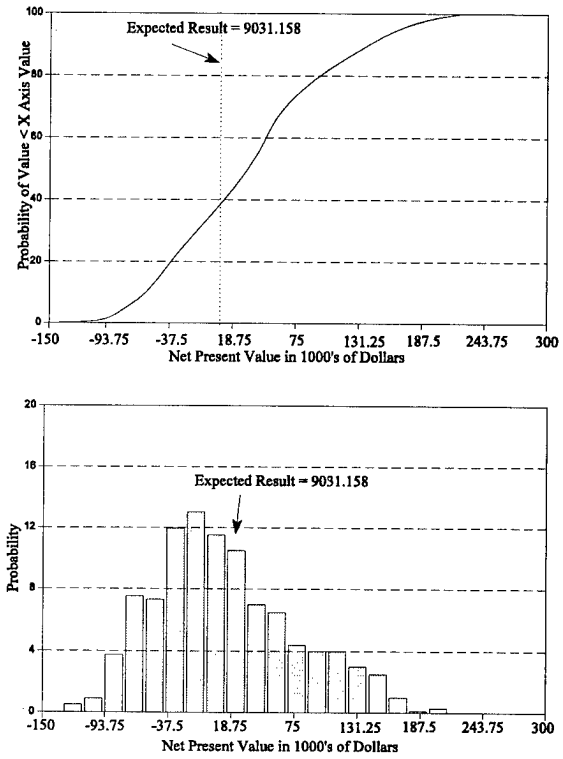


FIGURE D-7
EXAMPLE OF RECOMMENDED GRAPHICAL FORMAT FOR COMMUNICATING RISK INFORMATION AS PROPOSED BY MORGAN AND HERION (1990)

analyzed data from a study that evaluated the effectiveness of different approaches for explaining radon's risks to households in a radon monitoring program undertaken by the New York State Energy Research and Development Authority (NYSERDA) during the late 1980s. In that New York study, four information booklets were used to convey information about radon's risks. The information booklets differed in two main ways: (1) the extent of quantitative information about the lifetime risks of lung cancer from radon; and (2) the use of a directive format that emphasized the EPA Action Guideline and instructions for action (labeled Command) versus one that encouraged personal judgment and evaluation (labeled Cajole). The EPA Action Guideline emphasized four picocuries as a type of safety threshold; readings below four did not require action while those above four might. In addition to information booklets, households in the studies were given information about radon readings for each of their respective homes over several measurement periods.

The main finding of interest reported by Smith et al. (1993) is that differences in the information format used to convey radon risk information had a larger effect on the household's likelihood of taking some mitigating action than a doubling of their average living area radon reading. In particular, it seemed that emphasizing a threshold as part of descriptive material about radon increases the likelihood of mitigation. People seem to be very sensitive to information that suggests that they have moved above an explicit target value for a risk such as radon.

The results of Smith et al. (1993) and many related studies on reference point effects in risky choice suggest that the communication of risk information be formatted in terms of a few clear target values. For example, information relating to the "hundred-year flood level" seems to play an important reference role in the Corps of Engineers.

Understanding Probabilities

While a reference concept like a "hundred-year flood" may play an important role in managing floods, there is evidence to suggest that probabilistic concepts like a "hundred-year flood level" are often misunderstood. Helping people to understand probabilistic concepts like a "hundred-year flood level" should also be viewed as part of the risk communication effort.

A nice example of how the framing of probability information might impact behavior in the context of a flood insurance program is provided by the Apex Insurance Corporation case (Harvard Business School, 1992). That case describes a firm trying to sell flood insurance to the owners of mortgaged properties in a designated flood zone. According to the case, the law requires that mortgaged properties in a designated flood zone be insured against flood damage. However, as reported in the case, only about 10% of the properties that should have flood insurance did so.

One reason why many people may not buy flood insurance is that people don't really understand a "hundred year flood level." The following material taken from the Apex Insurance Corporation case nicely illustrates that point:

> For example, when customers asked us to define a special flood area, if we used the government definition that it was an area that flooded once or more every 100 years, the typical response was "I don't plan to own my house for 100 years." On the other hand, if we told them that there was at least a 1% chance of a flood every year, they were more satisfied. We also found that certain statistics helped convince them of the need for flood insurance. For example, the statistic that 26% of all houses in flood zones are flooded during the life of a 30-year mortgage versus only 1% that have fires proved to be very persuasive (p. 8, Apex Insurance Corporation Case: Harvard Business School, 1992).

The quote given above also nicely illustrates the point that framing or presenting the same information in different ways can improve the communication of risk information. Study after study in behavioral decision research has demonstrated the power of framing, and re-framing, information in different ways (Payne, Bettman, & Johnson, 1992).

CONCLUSION

Risk analysis is a powerful set of tools for helping decision-makers deal with a complex and uncertain world. However, an understanding of the psychology of decision behavior can plan an important role in both (1) communicating the value of risk analysis as a method to executives, and (2) communicating the results of a risk analysis to others.

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ANNEX D-1

GRAY CAP AND CLOSURE COMPANY CASE STUDY

GRAYCAP AND CLOSURE COMPANY
PART A

Fuqua School of Business
Duke University

1990

This case is a much modified version of a case originally developed at the Harvard Business School. The financial information and dates have been changed along with the text. A number of Fuqua School faculty including John Forsyth, Dan Laughhunn, John Payne, and Rick Staelin have contributed to this case. The case has been designed to be used with various computer-based decision aids. (10/90)

GRAY CAP AND CLOSURE COMPANY (A)

On December 3, 1978, the executive committed of the Gray Cap and Closure Company met to consider a proposal to introduce a new plastic-lined cap for the ale bottling industry in the beginning of the next calendar year. The members of the executive committee were Mr. Kenneth Lindstrom, chairman, Mr. Jonathan H. Morgan, factory manager, Mr. Charles H. Dewart, sales manager, and Mr. Ralph T. Jones, treasurer. Meeting with the committee, in advisory capacities, were Mr. Harrison E. White, new-products manager, and Mr. Otto Brenckler, head of operations research.

Gray was a medium-size firm engaged in the manufacture and nation-wide marketing of bottle caps and jar closures to the food and beverage processing industry. In the 49 years since its founding in 1929, the company had grown to be the third-largest producer of caps and closures in the United States. During 1978, Gray's sales were expected to be about $25,300,000 representing about 10$ of the total cap and closure market.

THE CAP AND CLOSURE INDUSTRY

Currently, the largest producer of caps and closures was the Roberts Cap Company with 40% of the market; in second place was the Montgomery Manufacturing Company with about 30% of the market. The remaining 30% was split among Gray and 15 smaller companies. The largest of these smaller companies had only 5% of the total market.

Caps and closures fell into two categories, standard and special. For a cap or closure to be considered standard, it had to be used on standard capping equipment for standardized containers or bottles filled with contents not reacting upon or being reacted upon by the standard cap material. If any one of these conditions was not true, the cap or closure was considered a special item.

The standard-cap market was characterized by high volume and low profits. For example, 70% of Gray's unit volume in 1978 consisted of standard items; yet these items produced only 50% of Gray's net dollar sales and 20% of the net profit. The purchasers of standard caps were extremely price conscious. There was little or not quality difference among competitive standard caps, as these were produced on standard cap punches with materials meeting certain minimum specifications. As a result, there was a great ease of entry into the standard-closure field. In fact, all that was needed to manufacture and sell standard caps was a cap punch and a salesman.

Special-cap sales were split among two kinds of companies: those who carried on research and development to introduce basically new products, and those who tried to copy the new designs being introduced. The innovators spent considerable time working with cap users to determine their exact requirements, and expended research and development funds and effort to satisfy these requirements. The Gray Cap company took pride in being a technology leader. To carry on effective product innovation, a company had to have an experienced and capable technical staff as well as substantial amount of capital to finance the development of a new product. In Gray's experience, for example, an "average" of at least four years elapsed between the time research and development was initiated and the time when a newly developed product was ready for introduction to the market; research and development investment had averaged about $250,000 for each new product marketed. To copy a special product, on the other

hand, required little investment in research and development and a minimum of sales-engineering activity.

To compensate for this difference in investment, the customer was usually willing to pay a somewhat higher price to the firm which developed a product to the customer's specification. This customer loyalty was not sufficient, however, to permit the innovator to change any price he desired. An excessive price difference caused a substantial shift in sales from the innovator to the copier.

This kind of market situation forced a company introducing a new product to set a price low enough to make it difficult for copying firms to cut the price and still obtain an adequate return on the required investment in equipment. Furthermore, even if the newly developed item happened to be patentable (an unusual circumstance for the cap and closure industry), an excessively high profit margin would attract other companies to do development work of their own to bring out improved competitive products.

GRAY'S NEW ALE CAP

For the particular closure being considered by the Gray executive committee--the ale bottle cap with a new plastic liner--the company already had spent $225,000 for research and an additional $10,000 for sales and engineering; $100,000 of this research expense had been capitalized at the end of 1978. Of course, no one wanted to see that money go to waste.

The impetus of starting the research effort on the ale cap back in 1974 had resulted from the introduction at that time of a new ale cap by the Roberts Company. This Roberts cap had been so much of an improvement over the Gray cap then being sold to the ale bottlers, that by 1975 Gray's market share of the ale industry had dropped from close to 60% to almost nothing. Gray had, as a consequence, engaged in a development program rather than simply produce a copy of the Roberts cap because the executive committee did not feel the company could sell a copy at a high enough price to achieve an adequate return on the required investment. The research and development staff had worked very hard on this new ale cap and were proud of the product.

Historically, Gray and Roberts had dominated the ale market, and were the only companies to have expended much research effort in that field in the past. Mr. White, the new-products manager, was certain that Roberts had not done any development work on ale caps over the past four years. His opinion was based on the facts that (1) Roberts already had a commanding share of the ale cap market, and (2) R&D was expensive, and that (3) Roberts had never cannibalized their own products in any other markets. He also felt it was highly unlikely that any of the other companies in the field had decided to try to break into the ale-cap market with developments of their own.

If the executive committee would authorize the introduction the new ale cap, Mr. White recommended that it be priced at $135 per thousand-dozen, the same price as the competitive Roberts product; any other price, he felt, would result in risks clearly not commensurate with the gains. A lower price might be expected to keep out competition. However, Roberts would certainly interpret a lower price as a break from the usual pattern in the special-closure market of competing primarily on the basis of product features rather than price and might be expected to retaliate on other products. Mr. White was certain that a price of less than $130 per thousand-dozen would trigger substantial retaliation by Roberts. On the other hand, a higher price might cause some loss in potential sales to the existing Roberts cap and would most likely add to the risk of being copied.

Although a "skimming" policy of pricing as high as $145 per thousand-dozen, at least until Roberts was to enter, might be a possibility, White felt that Gray would probably have to lower their price back down to $135 unless Roberts decided to go with the higher price also. Nonetheless, Mr. White still felt that going with the current price of $135 per thousand-dozen was the right thing to do. The executive committee decided to concur with Mr. White's price recommendation and the meeting then returned to a discussion of sales potential at the price of $135.

MARKET SIZE AND SHARE

Mr. White estimated that the total industry sales for 1978 would amount to 9,700 thousand-dozen (i.e. to 116,400.000 units), and he forecasted 10,000 thousand-dozen for 1979. He believed that the new cap was sufficiently good to capture an estimated 70% of the market at the price of $135. "Of course, even though we've worked with the customers and think we know what they want, introducing a new product is still something of a speculation. We can't tell for sure whether the customers will buy until the product is actually on the market, although the degree of customer acceptance is pretty well established by the end of the first year after introduction. Any delay in some customers accepting the product in the first year is balanced by the extra people who try the product once and don't adopt it, so that this 70% figure would even be valid in the first year."

"A 70% market share certainly sounds attractive," Mr. Lindstrom, the chairman of the executive committee observed, "but for how long do you think we can keep it?"

"The thing that worries me most," Mr. White responded, "is the possibility, which at the moment sounds remote but which may, nevertheless, be right around the corner, that the market for our new ale cap will disappear entirely. Some completely new breakthrough might simply obsolete glass bottles as ale containers. I've heard about research being done by several of the chemical companies on plastic bottles with breakoff tops, for instance. Currently, they still have the problem caused by contact between ale and plastic which affects the taste of the ale within a few weeks after bottling. However, they may be able to overcome this problem one of these days. As you know, we've had a similar problem with the plastic liner in the new ale cap, but fortunately that's not in constant contact with the ale. It takes about a year before the new liner starts to affect the taste of the ale and by that time the ale would be sold and drunk."

"Then again, it's possible that the canners will find some new gimmick to drive the bottlers out of business entirely. The flip top certainly gave us all a scare, but although that hasn't panned out as the canners hope it would, the next innovation may. The one thing we're certain of is that no product of ours lasts forever; if you look back, it's been our experience that every year about one out of 10 of our special products becomes obsolete for one reason or another that you just can't predict in advance. Usually when that happens, we can sell our inventory and that's about it."

"I appreciate the problems of predicting obsolescence," Mr. Lindstrom interjected, "but that's certainly not our only problem. Surely, if we were to get the 70% market share which you predict, Harrison, you wouldn't expect the competition to just sit on their hands and do nothing about it, would you?"

"Certainly not," Mr. White replied. "There are two major ways in which we can suffer attrition of our market share: through copying by the small fry and through new-product development by Roberts. If we do achieve 70% market share—and remember, that figure's just by best guess, and by mo means a

certainly—we will almost surely run the risk of competition from both sources."

"With our price of $135 per thousand-dozen the copiers won't be able to undersell us by much and still make money—especially since they can't afford the expensive special-purpose equipment that we use that enables us to keep our direct manufacturing costs low. These fly-by-night outfits do keep their overhead costs down, though, so they can squeeze a little profit out even if they do cut prices. Of course, it would be easier for them to compete if we had selected a higher price originally. In any case, it would certainly take them a year to figure out how to copy us; the typical pattern is for the copiers to take about 10% of our business in the second year of a new product's life, and about 15% in the third year. They can erode our share some more if they work at it, but we've taught them a lesson twice by clobbering them with price cuts on other products after they got too greedy by stealing more than 15% of our business. If we don't get 70% of the market, I would still expect pretty much the same pattern of copying, that is, having 10% of our initial market share stolen after the first year and 15% after the second. Even if our market share turns out to be much smaller than I expect, some little guy will find it profitable to steal part of it."

"As far as new-product development by Roberts is concerned, they just haven't got a chance to get anything out that improves on our product for at least two years; in any year after that I'd guess that they would have maybe one chance in four of coming out with a new and substantially better product than ours--at least, that's how I'd appraise it if we got a 70% share in the first year and we priced the cap at $135 per thousand-dozen. So, I think Roberts will most likely enter in the sixth year. If we got a share more than 70%, Roberts would probably put more effort into its development program, and might have a higher chance of success in any year after the second; by the same token, if we got a lower share, they'd probably operate with less intensity, so that their chances of success will be less. For example, I think the chance of Robert's entry in any year after year two drops to about 1 in 6 if our initial share is only 40%. Let me point out, however, that if and when Roberts does come out with a new cap, they won't necessarily recapture the entire market. They did it last time, and we may do it this time, but they can have a dud, just as we can. If I had to guess at the impact that Roberts will have when they enter with a new product, I would have to assume that they would drop our market share to about 30% of what it was before they entered. It's pretty reasonable to assume, though, that whatever they steal from us will be stolen from our copiers in roughly the same proportion."

"How will the new ale cap cut into the sales of our existing product?" Mr. Lindstrom asked. "It seems to me that some of our customers will simply substitute the new cap for our other product. If this is so, then we will be stealing sales from ourselves and ought to reflect these lost sales in our assessment of the new product."

"I guess you're right," Mr. White responded. "But if we don't steal it from ourselves, we should eventually anticipate further erosion of our very small current market share. I suggest that we leave sales erosion on our existing product out of our discussion because this is going to occur whether we introduce the new product or not."

GROWTH OF MARKET

"So far we've talked quite a bit about the share of market that we'll have under various circumstances, and you, Harrison, have given us a forecast of the size of next year's market," Mr. Lindstrom said, and then, turning to Mr. Brenckler, the head of operations research, he continued. "Otto, your people have been concerned with long-range forecasting; have you done anything that

would help us to estimate the growth in the bottle-ale market?"

"It happens that we have been looking at the growth patterns of a number of foods and beverages," Mr. Brenckler replied. "Albert Ando, an econometrician on my staff, has been working on growth models for projecting future demand of these items. In anticipation of this meeting, he and I have taken a look at the factors affecting demand for bottled ale, and he is now working on a growth model for this product."

"We have found that the ale market as a whole has maintained an annual growth rate of roughly 4%, but the growth rate of bottled ale has been closer to 3% per year, owing to the fact that cans have been slowly but steadily obtaining a higher share of the market. But, although these trends are clearly perceptible over the long run, there have been quite wide year-to-year swings in demand. Sometimes it's hard to know why these swings occur, while, at other times it's clearly traceable to some factor that can be pinned down in retrospect, such as an unusually hot summer, or a temporary change in consumer preferences for ale versus beer, but even in these cases it's practically impossible to predict the swings in advance." Mr. Brenckler said in summary that a 3% annual growth in the market was about as good an estimate as he could make of long-term trends, but he emphasized that year-to-year fluctuations might result in occasional declines in demand as well as in spurts which, over the short run, appear to be harbingers of a new growth rate, but which would probably be of no long-term significance.

PRODUCTION EQUIPMENT AVAILABLE TO MANUFACTURE THE ALE CAP

Mr. Lindstrom next called on Mr. Morgan, the factory manager, for a discussion of the means of producing the new ale cap if it were introduced. Mr. Morgan reported that the only equipment available on the market that would be capable of producing and packaging the new ale cap was a Gordon Model K semi-automatic cap punch. Some modification of the machine would be necessary for the purpose at hand, but no other equipment would be required for the manufacturing and packaging of the ale caps. The total cost of the equipment, including delivery, installation, and modification, would be $250,000.

The machine would be operated by a team of four men working simultaneously, and could produce and package at the rate of 2.5 thousand-dozen caps per hour, but time devoted to maintenance would reduce the productive output of the machine. Two thousand hours was considered a normal work year, but up to three thousand four hundred hours could be obtained by using a large pool of qualified workers to work overtime.

Mr. Morgan believed that the machine operators could be moved to other jobs when they were not needed for ale cap manufacture, and foresaw no difficulty in transferring them to other jobs even for short periods, when maintenance was being performed. The operators were paid $12.50 per hour for regular time, with a 50% overtime premium.

Maintenance on the machine, both for preventive and emergency repair purposes, would be performed by a skilled mechanic. He was paid $15.00 per hour for regular time, and also received a 50% overtime virtually at a moment's notice, even during overtime hours, as a number of them lived nearby. Each hour of maintenance would cost about $15 for materials, in addition to the labor cost.

Mr. Morgan said that he would plan to schedule 100 hours of maintenance in the first year plus an additional three hours for each 100 production hours in the first year. He also thought the fraction of all

maintenance work conducted on overtime would be in the same ratio as regular time to overtime. "There's no problem about maintenance in the first year," he continued, "but the only thing I can predict now about future years is that maintenance will increase as the machine ages. Gordon makes perfectly respectable machinery, but every manufacturer produces his share of lemons. Besides, we've got to do some tinkering on this machine in order to adapt it to the kind of production we've been talking about. We can make almost anything run, and keep it running, just about forever if we have to, but the maintenance cost can eventually kill our profit margin. If I had a couple of year's experience with this particular machine I could be more precise about these costs, but at the present time, it's just anybody's guess. My best guess is that we will experience a rate of growth in maintenance hours of about 5% each year. This rate of increase ought to apply to both the schedule and unanticipated maintenance."

In addition to the Gordon Model K cap punch, Mr. Morgan also indicated that inspection of the new ale cap prior to packaging would require use of some fairly sophisticated testing equipment. Mr. Morgan stated, however, that there would be no need to purchase nay new testing equipment, since in his opinion, the current equipment had enough spare capacity to handle the new ale cap as well as all other current products. In fact, Mr. Morgan was of the opinion that there would be enough spare capacity to handle the new ale cap and all existing products for about three years. On this basis, Mr. Morgan recommended that no cost be assigned to the new ale cap for the use of the testing equipment.

ACCOUNTING DATA

The cost-accounting department had provided the following factory-cost estimate for producing 1,000 dozen caps on the Gordon machine on regular time:

Direct Materials: $80.00	
Direct Labor:	
Machine operation*	$ 4.00
Inspection an packaging**	$ 3.20
Total direct labor	$ 7.20
Overhead: 100% of direct labor	$ 7.20
Total factory cost	$94.40

* Figured at regular time. Overtime premium is $2.00.

** Inspection and packaging were operations which would be scheduled during normal working hours, even if the machine were operated overtime.

The sales manager, Mr. Dewart, questioned the use of the 100% overhead rate, stating that the accounting department itself classified most of the overhead costs as fixed or semi-variable. The treasurer, Mr. Jones, defended the 100% rate by pointing out that as Gray had grown over the past ten years, its "fixed" costs had increased just about as fast as had its sales, and he could see no reason to believe that this would not continue to be true. Mr. Morgan, the factory manager, when questioned on the factory's overhead costs, presented the executive committee with the overhead budget which he had prepared for 1979 (see Exhibit 1). He noted in passing that it would be some time--in his judgement, 10 to 12 years-- before further additions to the plant would be needed even if the new cap were to be introduced. For this reason, Mr. Morgan did not believe that the new product ought to be charged anything for using up idle plant space. Spare plant space was a free good with zero cost, in his opinion.

In computing product cost, the company added a charge equal to 10% of selling price to cover research, selling and administrative expenses (40% of this represented sales commission). Exhibit 2 shows an October projection of these expenses for the year 1978.

FINANCIAL AND TAX CONSIDERATIONS

Mr. Jones, the treasurer, believed working capital equal to about 20% of the new sales would be needed for financing the new business, and that it should be considered as part of the investment. He also felt that the full $235,000 spent by the company previously, for research and sales engineering, was part of the investment. The sales manager, Mr. Dewart, countered that only the $235,000 portion of the past research cost which had not been written off should be included in the investment; he contended further that this past investment was "all the more reason" to introduce the new ale cap, since this was the only way the company could recoup this expenditure.

The equipment could be depreciated over a period of not less than ten years. It was anticipated that the machine would have a salvage value of 80% of book value. This figure reflects the cost of dismantling and removing it from Gray's premises. The company used the sum-of-the-years' digits method of depreciation for tax purposes.

Mr. Jones thought that Gray would be able to earn an average of 15% after taxes on investments made over the next ten years. Exhibits 3 and 4 show Mr. Jones' October estimates of the Company's balance sheet as of December 31, 1978, and its income statement for the year ending December 31, 1978. The company used a 52% tax rate in its investment calculations.

CASH FLOW PROJECTIONS

Mr. Lindstrom then asked Mr. Otto Brenckler, head of operations research, to prepare a ten year forecast of the cash flow that might result from an investment in the new ale cap projects. After a brief adjournment, the operations staff prepared a report that is shown in Exhibit 5.

Mr. Lindstrom, the chairman of the executive committee, thanked the staff for their report. Mr. Lindstrom noted that the people in the lab had worked very hard on developing a new closure. He also noted that he like Gray to be known as a technology leader. Although, he certainly understood the obligation of Gray's management to concentrate on doing the best they could for the shareholders. He then observed that this decision was not only a key decision for the company at this time, but that he felt that the type of decision process used would greatly influence the way a number of decisions would be made in the future. Of special concern of Mr. Lindstrom was how the Gray Cap and Closure Company might better deal with the uncertainties, risks, and conflicting values that often seemed part of strategic decisions.

EXHIBIT D-1-1
GRAY CAP AND CLOSURE COMPANY (A)

Budget of Overhead Expenses for 1979
Forecast Production: 500,000 thousand-dozen
Forecast Direct Labour: $5,000,000

Class of Expenses	Budgeted Amount at Forecast per Production	Budgeted Amount at 80% of Forecast Production	Budgeted Amount at 120% Forecast Production	Budget Change per 1,000 dozen
Supervision	$700,000	$700,000	$700,000	$0.00
Indirect labor	300,000	285,000	315,000	.15
Maintenance labor	500,000	475,000	525,000	.25
Unemp. comp. etc.	1,300,000 *	1,092,000	1,508,000	2.08
Maintenance mat'ls	700,000	665,000	735,000	.35
Supplies, heat, light & power	800,000	760,000	840,000	.40
Depreciation	700,000	700,000	700,000	0.00
Total	$5,000,000	$4,677,000	$5,323,000	

*20% of total factory labour

EXHIBIT D-1-2
GRAY CAP AND CLOSURE COMPANY (A)

October 1978 Forecast of
Breakdown of Research, Selling & Administrative Expenses
for Year Ending December 31, 1978
(in thousands)

Research Expense	
Salaries	$180
Supplies	10
Clerical	10
Unemployment compensation, social security, pensions*	38
Heat, light and power	5
Depreciation	7
Total research expense	$250
Sales expense	
Commissions**	$1000
Clerical	30
Unemployment compensation, social security, pensions*	206
Advertising	100
Supplies	1
Heat, light and power	1
Depreciation	2
Total research expense	$1,340
Administrative expense	
Executive salaries	$400
Administrative salaries	100
Clerical	50
Unemployment compensation, social security, pensions*	110
Supplies	5
Heat, light and power	10
Depreciation	55
Total research expense	$ 730
Interest Expense	180
Total research, sales, administrative, and interest expense	$2,500

* 20% of labour charges.
** 4% of net sales. Salesmen pay own traveling expenses out of their commissions.

EXHIBIT D-1-3
GRAY CAP AND CLOSURE COMPANY (A)

October 1978 Projection of
Balance Sheet as of December 31, 1978
(in thousands)

ASSETS:	
Cash and marketable securities	$2,500
Accounts receivable	2,500
Inventories	5,000
Total current assets	$10,000
Land	$ 500
Building, machinery & equipment -- cost	$9,500
Less: Reserve for depreciation	5,000
Building, machinery & equipment -- net	$4,500
Development expenses	500
Total fixed assets	5,500
Total assets	$15,500
LIABILITIES AND NET WORTH:	
Notes payable	$ 500
Accounts payable	1,000
Other accruals	1,000
Total current liabilities	2,500
Long-term bonds	2,500
Total liabilities	5,000
Common stock	$2,500
Retained earnings	8,000
Total net worth	10,500
Total liabilities and net worth	$15,500

EXHIBIT D-1-4
GRAY CAP AND CLOSURE COMPANY (A)

October 1978 Projection of
Income Statement for Year Ending
December 31, 1978
(in thousands)

Net sales	$25,000
Cost of goods sold:	
Beginning inventories	$ 4,500
Plus: Materials	10,000
Direct labour	5,000
Overhead expense	5,000
	$24,500
Less: Ending inventories	5,000
Cost of goods sold	$19,000
Gross profit	5,500
Research, selling administrative & interest expenses	
Research expense	250
Sales expense	1,340
Administrative expense	730
Interest expense	180
Total research, selling, administrative & interest expenses	2,500
Net profits before taxes	$ 3,000
Taxes	1,500
Net profits after taxes	$ 1,500
Dividends declared	500
Net addition to retained earnings	$1,000

EXHIBIT D-5

Staff Report

Memo to: Executive Committee

Subject: New Ale Cap Decision

Attached is a ten year forecast of cash flows resulting from an investment in the new ale cap project. The forecasts are based on the following assumptions:

1) Initial size of market is assumed to be 120,000,000 units. The overall market will grow at 3 percent.

2) Gray's cap will capture 70 percent of the market in the first year.

3) Copiers reduce Gray's initial market share by 10 percent in the second year and by 15 percent of initial share in the third year. The second figure remains the same until Roberts enters the market.

4) Roberts will enter the market in year 6. At that time Gray will keep 30 percent of the existing market.

5) The price of the product will remain fixed over the life of the project. The price is $135.00 per thousand-dozen.

6) Regular time production of caps is 5,000 thousand-dozen per year. Direct production cost on regular time (material and direct labor) is $87.20 per thousand-dozen. Overtime production, that is, production in excess of 5,000 thousand-dozen per year, has a direct product cost that is $2.00 more per thousand-dozen than regular time production.

   Because of capacity limits, total production cannot exceed 8,500 thousand-dozen in any year. If potential sales exceed 8,500 thousand-dozen, then actual sales will be reduced to 8,500 and the remaining sales demand will be lost.

7) In the first year of manufacturing operations, fixed hours of maintenance are assumed to be 100 hours per year and the initial rate of variable maintenance time is 0.03 hours for each hour of production time. Both of these will grow at 5 percent per year.

8) Total maintenance hours are divided between regular time maintenance hours and overtime maintenance hours based on the ratio of units of output produced on regular time to units of output produced on overtime. Regular time maintenance costs $30 per hour and overtime maintenance costs $37.50 per hour.

9) The expenditures for research ($225,000) and for sales engineering ($10,000) are not included in the analysis.

10) No inflationary effects are included.

11) Variable factory overhead is figured at $7.20 per thousand-dozen units made (sold).

12) Future research, sales, and administrative expenses are figured at 10 percent of revenues.

13) The total machine cost (including delivery, installation, and modification) is $250,000. Depreciation of the machine cost for tax purposes is based on sum-of-the-years digits and a 10-year life. If the life of a new ale cap is less than 10 years, than 80 percent of the undepreciated portion of the machine cost is recouped as cash.

14) Working capital requirements in any year are 15 percent of sales revenue. This assumes that 75 percent of working capital needs come from long-term capital sources (0.75 x 20%). The other 25 percent comes form suppliers at no cost to Gray. The cash flow associated with working capital investment in any year is assumed to occur at the beginning of the year. The total investment in working capital is treated as a positive cash inflow at the end of the life of the new ale cap.

15) The tax rate on profit is 52 percent.

16) Net Present Value (NPV) is figured using a 15 percent cost of capital figure.

17) Possible lost sales from other product lines are ignored.

APPENDIX E
COMMUNICATING WITH THE PUBLIC ABOUT RISK: WHAT YOU CAN EXPECT FROM THE MASS MEDIA

COMMUNICATING WITH THE PUBLIC ABOUT RISK: WHAT YOU CAN EXPECT FROM THE MASS MEDIA

by

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INTRODUCTION: THE 90s MEANS DOING MORE WITH LESS

When the United Nations declared the decade of the 1990s the international decade of natural hazards reduction, policy makers failed to anticipate that the problems facing the third world would move into the first with such a vengeance. Developed societies, including the United States, were faced with increasingly costly mitigation efforts surrounding specific events, for example the Los Angeles earthquake, Hurricane Andrew, the 500-year flood of 1993, as well as environmental problems that had festered, for example, clean ups of literally thousands of toxic waste sites, the reconfiguring of nuclear facilities such as Colorado's Rocky Flats to fit into a post cold war world, or the development of technologies to process and store other sorts of toxics, most prominently various levels of nuclear waste.

Solving such problems requires enormous amounts of money, something the third world has never had. But even developed societies found themselves in a financial squeeze. To many government agencies, the result seemed to be a public demand to move toward a no-risk society on a decreasing budget.

Risk communication, a term that was coined in the late 1970s, was originally touted by the Environmental Protection Agency as one way to take on these significant problems. As it was originally conceived, risk communication was defined as the unilateral sending of a message to the homogeneous public about a particular risk. Messages emanated in scientific and government circles and were designed to persuade those who received them to accept as accurate the information included in the message. The goals of risk communication under this model were education, persuasion and behavior change. The underlying assumption was that if the average person received enough information about a particular risk, he or she would respond logically, be persuaded, and act in accord with the scientific view. In this definition of risk communication, the message about risk traveled only one way--from the scientific and governmental communities to a largely uninformed public where it would be understood and accepted in a somewhat uniform fashion.

This was a primitive model of risk communication and, as with most models, suffered from the problems of reductionism on the sender's and receiver's end.

At the "front end" of the process, scientists became more able to conduct sophisticated forms of risk assessment. As risk assessment models became more realistic, scientists became involved in debates about the accuracy of the process, particularly in novel systems that combined both human and technical interaction (Perrow 1984; Pidgeon 1988). At the other "end" of the process, the response to risk communication, social scientists amassed a body of literature questioning assumptions about how risk messages would be received (Fischhoff et al 1982).

These changes in theory were a response to reality. Risk communication messages developed under the early model failed to have the desired public impact. Scholars, scientists and public officials were forced to develop a more complex theory to explain the real world in which they worked.

This paper delineates the common assumptions of that more complicated view of risk, the majority of which were outlined by the National Research Council (1989). After listing these assumptions, the paper will explore social scientific findings about the impact the mass media have on public understanding about various sorts of risks. The paper then explores how the public learns from and uses the mass media to understand elements of risk. Emphasis will be given to public understanding and use of media accounts of the midwest flood of 1993. Based on this

more complicated and contextual view of risk communication, the paper then outlines how the U.S. Army Corps of Engineers can use the mass media as part of the risk communication process. The paper concludes with some thoughts about what the mass media can and cannot be expected to add to that effort.

THE EMERGENCE OF A NEW RISK COMMUNICATION PARADIGM

While they have not been codified in a single document, the emerging risk communication paradigm is founded on the following:

1. Risk assessment is an evolving process. Risk assessment should not be incorporated into risk evaluation or risk communication without some discussion of the theoretical base of the assessment process itself. For example, at its current level of exactitude, risk assessment must assume that various factors do not interact with each other, even though the scientific community knows such an assumption is invalid in the human body and in the built environment. Risk assessment is a mathematical expression of probabilities, not an immutable explanation of the scientific situation. Further, like all forms of statistical analysis, risk assessment applies to the average--not the particular. Risk assessments can and do change over time; the public can become sophisticated enough to understand this reality.

2. Audiences will receive the same message about risk—communicated via the same medium—differently. One of the longest standing findings in the field of mass communication research is the debunking of the notion that the same message will be understood by individuals in same way (Lowery and DeFleur 1988). Psychologist Paul Slovic and his colleagues at Decision Research have extended this finding into the realm of risk *perception* by noting that experts understand risk messages differently than do non-experts (Gregory 1991). In fact, Slovic suggests the average person disregards base rates in favor of a heuristic including concepts such as fairness, controllability and dread. More recent work (Doble and Richardson 1992) has challenged Slovic's hypothesis, suggesting that on some issues, specifically the greenhouse effect, the non-expert may analyze risk in essentially the same way as the expert. In addition, people can be expected to understand specific risk communication messages within a societal and cultural history. For example, what the residents of the former Soviet Union understand by the phrase "nuclear accident" is informed by a 70-year-history of government repression and distortion of information, government policies that placed people in dangerous situations beginning in the 1940s, and the populaces' more recent experience with the Chernobyl catastrophe. Americans understand something quite different by the same phrase, although both groups of people rank "things nuclear" as one of the dread risks facing modern society.

People also bring personal qualities to understanding risk messages. In a research program aimed at improving risk communication, Ferguson and Valenti (1991a, 1991b) identified differences in behavior and responses to risk messages based on individual risk-taking predispositions. They found that information processing beyond mere attention varied with risk-taking type, the target of the message, source credibility and message content. Their work suggests effective ways to communicate risk information to risk takers, recognizing that some individuals pose a greater challenge than others to risk communicators.

The emerging risk communication paradigm acknowledges that expert *and* lay rationalities will be employed by the people who receive risk communication messages. Experts operating outside

their own area of expertise may also operate using both lay and expert rationalities. People will respond to the same message differently, differences dependent not just on the message but also on internal and external dynamics.

3. Risk communication is an interactive process with messages flowing both from the sender to the public and from the public to the sender. Because the risk assessment process is inexact, and because the members of the public may ask somewhat different questions about risk than the scientist/expert, risk communication must be viewed as a discussion between parties with significant but distinct stakes in the outcome of the conversation.

Some forms of risk communication, such as tornado or hurricane warnings, require quicker responses and provide much less opportunity for discussion than do other forms of risk communication, such as a decision about whether to field test a genetically engineered organism in the natural environment. However, the process of arriving at certain kinds of risk messages should be a public one in which various stakeholder groups have been consulted and their expectations and needs considered. By analyzing five case studies of risk communication, Krimsky and Plough (1988) note that government and corporate officials learned a great deal about public response to various risk messages through media accounts. News stories thus became one means of two-way communication, a method some groups use quite consciously in debates over public policy questions.

4. The goal of risk communication is not persuasion but rather public debate and discussion that leads to appropriate individual actions and/or policy outcomes. Risk communication has a purpose larger than the acquisition of scientific fact and the ability to more accurately predict to outcome of certain processes. These are important purposes, and ones not to be devalued. However, risk communication is fundamentally a public communication to which a variety of groups are expected to respond. Risk communication is part of the larger debate in which contemporary democratic societies engage. This debate is not a disadvantage—which early work in risk communication sometimes assumed—but is the goal of the process itself.

Public acceptance alone cannot legitimate public policy decisions that are not supported by the scientific community (Jasanoff 1990). But the intellectual history of the field of risk communication indicates that it is the scientific community which has often been considered the arbiter of truth. The emerging risk communication paradigm asserts that the public has a equal stake in framing truth and in evaluating and policy making process.

5. The people involved in the risk communication process are autonomous actors, capable of making informed decisions about risk and about their responses to it. All are assumed to have a stake in the process. While different groups may respond to different loyalties, for example loyalties to professional groups, all share a loyalty to themselves as individuals and to the community of persons to which they belong. As autonomous actors, they can be expected to value both the risk communication process and the results of that process. Autonomous actors pursuing enlightened self interest will often (but not always) make wise decisions not just for themselves but for the larger community.

6. New regulatory realities require increasing citizen participation. While the requirements themselves are laudatory, they also create some significant problems. Under the old risk communication paradigm, citizen participation was equated with agreement with the experts. Citizens were viewed as a single, homogeneous group. As the new risk communication paradigm makes explicit, citizens need to be involved in as many aspects of the

risk communication process as possible. Citizen involvement is essential at the following stages: (1) Defining the risk communication process itself; (2) Negotiating with the experts on what counts as evidence and who will be accepted as authoritative; (3) Articulating a variety of options as potential policy solutions; (4) Making certain that as many affected groups, including private citizens, business and industry, government officials, minority populations, are involved in the process; (5) Understanding that a public risk communication process may lead to changes in agency plans. These changes have other ramifications that agencies themselves need to be prepared to cope with.

Psychologist Baruch Fischhoff (1994) has suggested that the emerging risk communication paradigm itself represents a developmental process in thinking about risk. The stage both the academy of federal and state officials now have reached is the notion that the public(s) need to become partners in risk communication and mitigation efforts. Such a partnership is not without effort or strains:

> For any of this potential to be realized, risk communication has to be taken seriously. One cannot rely on undisciplined speculation about the beliefs or motivations of other people. One cannot expect to quiet a raging controversy with a few hastily prepared messages. One cannot assume that expensively produced communications will work without technically competent evaluations. Those who ignore these issues may be the problem, as much as the risk is. The price of their ignorance is borne by everyone concerned. The public is demeaned by the experts as being hysterical, while the experts are vilified as being evil....
>
> It must be recognized that avoiding all conflict is not a realistic, or even a legitimate, goal for risk communication. It should not and, in an open society, often cannot paper over situations where people are getting a bad deal. The best-case scenario for risk communication (and, indeed, risk management) is having fewer, but better conflicts. Some conflicts would be avoided by preventing needless misunderstandings, others by forestalling (or redesigning) unacceptable projects. Those that remain would be better focused on real issues.

7. Certain groups in the United States share a history and culture about risk which make them appropriately suspicious of government proposals and of their own abilities to have a positive (for that group) impact on government policy discussions. Student of risk have long understood that the riskiest "thing" to be in any culture is poor. And, in American culture, poverty is not equally distributed among ethnic groups. Inner city residents (i.e. African Americans and Hispanics) are much more likely than the average American to suffer from lead poisoning and other health problems related to environmental contamination. Native American homelands house a disproportionate share of radioactive waste sites. All three groups have been the historic recipients of legal discrimination, including discrimination over environmental policy. They seek what has become known as environmental justice, and they often frame debates over risk not in terms of scientific or technical competency but rather in terms of equality and fairness, what some scholars have called an environmental justice frame.

> Environmental risks in a community can evoke concerns about equity, moral responsibility, participatory democracy, control over decision processes and justice....In a community where a justice frame has been adopted and issues regarding the distribution of risks and benefits are salient, communications that only relate to technical or other aspects of the situation cannot result in a convergence of opinions. Policy officials will need to acknowledge the legitimacy of alternative ways of framing the

> issue and try to reach a negotiated or compatible framework... (Vaughn 1994)

Communities seeking environmental justice represent a challenge for risk communication. But it is a challenge democratic societies must be willing to sustain if decisions about risk are to achieve some popular consensus.

This new risk communication paradigm, thus, provides those engaged in the risk communication process with a much a different set of goals than those that dominated earlier thinking about risk communication. Further, the mass media can and do interact with the public, decision makers, elected officials and scientists/experts at many points in the risk communication process. Understanding these potentials is one element in creating a risk communication campaign that promotes discussion and dialogue among a variety of constituencies.

THE MEDIA'S THREE-PART ROLE IN RISK COMMUNICATION

Social science research and normative theory suggest the mass media have three roles to play in communication about risks, hazards and disasters. They are:

(1) The media function as a part of both a short-term and long-term warning system;

(2) The media function as an evaluator of response to hazards, disasters and risk by a variety of groups associated with both specific events and larger issues. This evaluation function is not uni-directional. While members of the public learn from media accounts, private citizens and other stakeholder groups can also use the media to communicate their concerns to each other and to those in power;

(3) Indirectly and cumulatively, the media create a culture of expectations and understanding regarding risk, hazards and disasters.

What follows is a review of the scholarly literature pertaining to each of these roles supplemented with specific examples from a public opinion survey conducted in Missouri in April 1994, in the wake of the flood of 1993. In most cases, the results of this particular survey support earlier findings in the scholarly literature. Since the U.S. Army Corps of Engineers is concerned specifically with risk communication about floods, the findings of this survey may help guide future actions. The telephone survey was conducted by the Center for Advanced Social Research at the University of Missouri and was commissioned by and paid for by the Center for Disease Control and Prevention in cooperation with the Missouri Department of Health. A total of 1,998 Missouri residents were randomly surveyed. Respondents lived in every county in the state where, the previous summer, 47 people had died and the entire state was declared a federal disaster area. as the result of a 500-year flood.

The Warning Role

The mass media appear to function most effectively in their warning role in the event of quick onset disasters, particularly those that are weather related. Content analysis of news coverage of a variety of events, (see for example Wilkins 1985; Walters, 1985; O'Brien 1991) indicate that the mass media provide citizens with information that disasters are imminent as well as some information about appropriate response to such threats. In fact, the Federal Emergency Management Service has developed a variety of plans to work with news organizations in various localities to provide accurate information to the news media about impending events, particularly hurricanes. Scholarly research

indicates that the broadcast media, particularly television, often serve the role of community bulletin boards during event onset (Wilkins, 1985), thus providing critical information in a very timely fashion.

Just as important, it appears that the public expects the mass media to adopt this bulletin board function in times of disaster. The broadcast media, specifically television and radio, were named as the "primary source of information about the 1993 flood" by more than 86 percent of those surveyed. People relied on the broadcast media for information about local flood crests (85.9%), where levees were breaking (90%), where to go for shots and vaccinations (72.6%), where sandbaggers or other volunteers were needed (86.3%), weather forecasts (96.5 %), bridge, highway and street closings (89.7 %), and "what to do if you were exposed to flood water", (79.8 %). In each of these instances, television was the medium of choice by a substantial majority of those who turned to the mass media for quick-onset flood information.

Other studies have indicated a similar pattern on a national level. For example, most people learned of the Los Angeles earthquake from the news media, specifically from television reports.

However, some of the information news organizations provide may be problematic, sometimes due to the unpredictable nature of weather related hazards as well as the vagaries of the news gathering and dissemination process. For example, news reports may warn of an impending blizzard without clearly defining the term (Wilkins 1985). Other sorts of quick onset events are even more difficult for journalists to anticipate. Americans learned of the 1989 Loma Prieta earthquake because they tuned in to watch the world series--not the news.

The media's ability to function as a warning mechanism is much more problematic for slow-onset hazards. Part of this problem rests with the definition of news itself. If news is assumed to be a report of an event, then reporting about an event that might or might not happen falls outside this definition and hence remains unreported. For example, sociologist Charles Perrow, in his book *Normal Accidents,* notes that in contemporary society it is expected that chemical and other sorts of manufacturing plants will malfunction. The mass media do not warn of such generalized impending events, rather they wait for a specific event, such as the Bhopal chemical spill or the more recent plant explosion in Philadelphia, to occur. Environmental hazards, such as ozone depletion, acid rain, the creation of toxic waste as opposed to their cleanup, or the greenhouse effect, are also subject to this kind of event orientation. In addition, news organizations function within a community context--at least when they are covering certain sorts of environmental risks. Smaller news organizations, for example weekly or small daily newspapers, have been found to underreport certain sorts of risks which might have an adverse impact on local economies or populations. Traditionally, the breaking of such news stories is left to larger journalistic organizations less likely to be effected by community backlash (Griffin and Dunwoody 1993). In their extensive study about media coverage about a variety of risks, Singer and Endreny (1992) noted media definitions of hazards and risk change over time but that "the media in all likelihood do not initiate the changes...the media are essentially reactive. Their definitions and selections of hazards for coverage are ordinarily shaped by sources other than the media themselves (p. 160)."

Another strand of research indicates that warning messages are most effective when they contain mobilizing information (Lemert 1989), that is information with precise instructions as to actions viewers or readers should take. In the event of some disasters, for example hurricanes, mobilizing information often takes the form of advice about when and how to evacuate and when and where to

seek shelter. Other such information may include directions on how to contact local emergency management officials, hospitals or other health professionals, or what sorts of food and other supplies it might be wise to stock, 800 numbers to call, etc.

However, specific studies regarding the effects of mediated warning messages about hurricanes and volcano eruptions have yielded equivocal results (Ledingham and Walters 1984; Perry 1989). Essentially, some groups of people disregard warning messages, sometimes because they have prior experience with the hazards and sometimes because they simply do not believe the warnings. Similar patterns are evident in public response to other sorts of risks, for example cigarette smoking. People who receive mediated warning messages also tend to corroborate them with friends and neighbors before taking specific actions. Consequently, mass communication scholars have concluded that mediated warning messages about a variety of disasters and hazards can be viewed as only partially successful in inducing learning about specific hazards or in promoting behavior change. The more deeply ingrained the behavior, for example, sexual behaviors that put one at risk for contracting the AIDS virus or living on a family farm for multiple generations, the more difficult it is for mediated warning messages to have the desired impact.

On the other hand, mediated warning messages coupled with other forms of communication, for example interpersonal communication and/or communication from health professionals, have been shown to be capable of inducing behavior change on issues of personal risk. The Stanford heart studies (Farquhar et al 1984) conducted in the 1970s found that an integrated communication campaign including mediates messages, interpersonal contact and communication through physicians was effective in encouraging people to adopt a more "heart healthy" life style. Recent news reports about the use of condoms among sexually active teenagers to avoid exposure to the AIDS virus may be viewed as an example of the synergistic impact communication through a variety of channels can have on risk taking behavior.

Significantly, when the risk is warning about a quick-onset event, the news media most frequently function as a partner to government. (The outstanding exception to this generalization is in the reporting of urban crises, where media coverage has been vigorously critiqued by scholars as well as working journalists.) But, in the event of natural or technological quick-onset disasters, journalists tend to be less critical in their coverage of warning about impending events and in covering the immediate impact of the disaster than they are in subsequent news reports about clean-up efforts or the formation of risk mitigation policies. In this sense, when the issue is warning or disaster onset, the mass media can be expected to abandon their role as a check on government for a brief time in favor of a role that advocates the preservation of human life and property. As the next strand of research indicates, however, this partnership is both limited and short lived in some important ways.

The Evaluation Function

Much social science research has been devoted to media coverage of disasters, hazards and risk—most often after a specific event. The bulk of this analysis has focused on journalists, their behavior and the content of their news accounts. These findings cluster in six distinct areas:

(1) Media coverage will be episodic and will focus on discrete events. In time of crisis, journalistic routines may be truncated. During and immediately after a hazardous event, journalists often tend to function from a "command post" point of view (Quarantelli, 1981). This means they focus on the

disaster response through the eyes of those directing the effort. Other scholars have noted that news stories tend to rely heavily on government or other official sources for information contained in news accounts. Average citizens are cited as sources much less often in news stories, although television reports tend to source stories using average citizens somewhat more frequently (Nimmo 1985; Wilkins 1987).

Scholars have also noted that traditional norms of journalistic behavior, for example checking facts with second and third sources or passing stories through layers of editors, changes significantly in times of crisis. Part of this change is the result of technological advances; satellite and other remote capabilities now make it possible to broadcast "live at 5" with the resulting capacity for high drama and the distortion that arises from a lack of context or time for journalistic reflection. While scholars have found that factual inaccuracy is not a major problem with American media accounts (Scanlon, Tuukka and Morton 1978), presenting a distorted view of damage or clean up problems by featuring one geographic locale in what may be a widespread event has been found to be more common (Smith 1992).

In fact, at least one scholar believes that the ability of television camera crews to arrive at the scene of a disaster quickly is changing how print reporters do their jobs (Smith 1992). Since television can visualize an event, and transmit those images almost instantly, print reporters may adopt "television's version" of the reality of the disasters. Since the print media are more frequently charged with providing more in-depth information, this ability of television to frame an event may have a subtle but nonetheless deleterious impact on the print journalist whose in-depth stories probably will not resemble the immediate events aired on television. This is a particularly pertinent finding given the public's reliance on television for warning and onset sorts of information.

A variety of stakeholder groups, including for profit corporations, advocacy groups of many sorts, and even government agencies have learned to take advantage of this media tendency to report events by holding "pseudo events" to get coverage or prepackaging information in ways that reflect favorably on the group which created the message. As Singer and Endreny note:

> ...one of the most disturbing trends in mass communication is the increasing manipulation of media content, including the content of the news, in a deliberate attempt to mold public opinion and even behavior....In the short run, the exchange value of the image—"one picture is worth a thousand words"—is likely to enhance the story's credibility, even when it is false. In the long run, the practice is likely to erode further the confidence the public has in the media. (p. 170).

(2) Because news accounts are event oriented, issues of planning, mitigation and policy alternatives will fail to receive extensive coverage. The bulk of news stories will be printed and broadcast immediately during and after the event onset (Wilkins 1987; Smith 1992). These accounts will focus on the immediate event and tend to ignore the social, economic, political and scientific developments that may have contributed significantly to the problem in the first place. For example, news accounts of the 1984 Bhopal, India, chemical spill seldom mentioned the political decision to adopt the "green revolution" as a strategy for economic development. Without this decision, the chemical plant would never have been built and the specific tragedy averted, although alternate tragedies—starvation—might have become more likely (Wilkins 1987). News coverage of the 1993 flood reflects a similar shallowness of analysis, although there were some important exceptions, for example the St. Louis Post Dispatch's lengthy series of the flood and its policy implications.

Scholars label this focus on the immediate event "decontextualization" (Altheide 1976). Psychologists, too, have a label for this human tendency to think in terms of the individual and the personal instead of the systemic and the general: the *fundamental attribution error* (Fischhoff 1985). Most traditional news accounts reflect this cognitive problem. In fact the very definition of news, which emphasizes events, drama, conflict, and people—even on issues of risk—tends to provide a frame in which individual people are held accountable for actions that have at least some basis in more institutional and systemic realities (Wilkins and Patterson 1987). Even ethically commendable health campaigns have been criticized for this basic flaw.

And it is worth repeating that the focus of such campaigns is, once again, the individual—individual smokers, not R. J. Reynolds; designated drivers instead of a ban on liquor advertisement. Thus these proposed campaigns insidiously reinforce the notions of individual responsibility and individual blame for what may, more appropriately, be regarded as largely socially determined behavior (Singer and Endreny 1992, 171).

Normative theory suggests that one of the news media's fundamental responsibilities in democratic societies is to make the public aware of policy options. While studies confirm that the news media are reactive in their coverage of risk, it is unclear how government and agency officials can take these journalistic predispositions and begin to help journalists reconceptualize risk from a series of events to a discussion of policy alternatives. However, such a reframing of risk from single event to a series of policy alternatives is essential for effective risk communication.

(3) News media will employ predictable narratives to tell stories of disasters and risk. Despite the enormous variety of media outlets and the competitive nature of the mass communication system, news stories from different media outlets do not vary greatly in content. While some scholars have noted that the three major television networks provide slightly different narratives about major disasters (Nimmo 1985), these narratives are only subtly different as opposed to providing substantively different information and interpretations. In fact, some researchers have noted that all news accounts, regardless of medium of distribution, reflect certain enduring cultural values, and that the cultural values of leadership, responsible capitalism and a need to maintain social order are often reflected in news accounts of a variety of disasters, hazards and risks (Gans 1979). Analysis of news coverage of environmental issues indicates that environmental stories often focus on the possibility of a technological "fix" to environmental problems and that underlying values of progress and human (as opposed to ecological) health are also reflected in journalistic coverage of the environment (Wilkins 1993). Such a framing, which owes a great deal to the Enlightenment's vision of humanity as master and controller of nature, makes it difficult for journalists to explore some sorts of policy options, for example returning river land to the natural ecosystem by reconstructing wetlands rather than building levees. Framing news accounts about risk through the "humanity as master of nature" paradigm also leads to some frustration on the part of the public, which appears more concerned about issues of health and permanence and somewhat skeptical about the capacity of technology to solve certain sorts of problems. Citizens often raise such issues, only to find them omitted from news accounts or treated in a manner that de-emphasizes their importance from the citizenry's perspective.

Journalists also tend to cover science (and hence risk assessment when it is treated as science) in a predictable fashion. In most news stories, science is treated as a string of discoveries with the scientist as hero rather than as a process of discovery (Nelkin 1987). Journalists often portray scientific disagree-

ments through a "dueling scientist" scenario, where in the name of balance scientists are lined up on opposing sides a question to "shoot" each other verbally without any mention of the weight of scientific opinion on particular controversies. Scientists are seldom forced to explain the value system that underlies their decisions; indeed, journalists often treat science as value neutral. At the same time, scientists are seldom the major source for stories about risk. That role is left to political and government officials and, in some specific events, spokespersons for a variety of interest groups including industry and lobbies of various sorts. However, Singer and Endreny found that journalists were quoting a wider variety of sources—including scientists—in their stories about risk in 1984 than they were in 1960 (Singer and Endreny 1992).

(4) Media coverage will emphasize victims, primarily through pictures and video. While some have criticized news accounts of risk as coverage through horror stories, this focus on individuals arises predominantly from professional demands that journalists make stories accessible and interesting to individual viewers and readers. As indicated earlier, the fundamental attribution error also contributes to this emphasis on victims.

However, a lack of readily identifiable victims, for example on environmental issues such as the greenhouse effect, makes news coverage problematic. Without a "hook" or "news peg" like a victim, it becomes more difficult for individual journalists to sell stories to their editors. This is a more subtle reason that coverage about policy issues is seldom given as much air time or space. Risk policy debates lack readily identifiable victims rendering television stories more difficult to construct and allowing print editors to assert that "it's not really news yet".

(5) Media coverage will emphasize the costs of risks rather than the benefits. Since risks are often framed as disastrous events, the costs are often easy to recognize: bodies and property damage. The benefits are sometimes much more difficult to specify.

However, the tradeoffs between costs and benefits is one area of risk where expert and lay rationalities diverge substantially. Risk assessment tends to weigh costs in terms of building or employing technologies of various sorts; risk perception tends to frame costs in terms of equity, fairness, controllability and peace of mind. Journalistic accounts, often with the goal of balancing competing views, will print or broadcast such concerns. What journalists do much less well is to alert readers and viewers that a different calculus is being employed by different sources--that different, but equally important, questions are being asked.

(6) All of the foregoing allow the media to function as an equalizer of perspectives on risk and to promote symbol formation around issues and events.

There is some research to indicate that it is the cumulative effect of media coverage that is pertinent to understanding public response to media coverage of hazards, disasters and risk. When psychologists question people about the likelihood of death or serious injury in risky situations, people tend to say that they are at higher risk for events that have received a great deal of news coverage than for events that have not. Americans believe that they are more likely to be struck by lightning (a statistically unlikely event) than to be seriously injured in an automobile accident (which has a one in three chance of occurring during the average American's lifetime). This long-term impact cannot be traced to a single news story or event or even a set of news stories. However, social scientists believe that accumulation of news stories during a lifetime does have the pronounced, yet subtle effect of providing a knowledge base (which may include both accurate and inaccurate information) about disasters and risk (National Research Council 1989).

Krimsky and Plough assert the mass media perform the important function of symbol formation on issues of risk. They note that it is difficult to anticipate which of several sources, from interpersonal to mass communication, will dominate a risk communication controversy. Messages about risk may also become entangled in unpredictable ways. Finally, they note that the media do not tend to reconstruct a particular risk communication, but they do tend to dramatize, highlighting existing uncertainties, dissonance and conflicts. "The media are a great equalizer of perspectives on risk...The media also play an important role in fixing images (Krimsky and Plough 1988, 302)." While research in this area is still in the formative stages, scholars believe that television plays a particularly significant role in fixing images of disasters and risk in the public mind. Further, these images help frame a variety of risk debates, lodged as they are in both human memory and cultural experience.

While scholarly research has "taken apart" media coverage of disasters, hazards and risk, normatively journalist's overall goal in producing and distributing news stories is to allow the public to evaluate how various institutions, and individuals, have responded to particular policy problems or situations. This evaluation function is a sharp change in role from the partnership the media and various institutions often develop during times of crisis. This shift in journalistic role, often without apparent warning, does engender suspicion and distrust. Hazards management officials are wary of journalists because of the evaluation function itself. No one who has done his or her best to save lives or present policy options enjoys having individual or organizational efforts criticized in the very public forum media accounts provide. This attitude is particularly prevalent in private industry. And, journalists can make a hazards manager's job more difficult. It is possible for representatives of more than 100 separate news organizations to descend on the site of a disaster within 48 hours, no matter how remote the location (Smith 1992). Dealing with the media becomes a hazard in and of itself.

However, it is important to note that under the emerging risk communication paradigm, public discussion and debate are a goal. The evaluation function provided by the news media can be a significant asset, despite the liabilities. The news media will behave in predictable ways; understanding what to expect can decrease some of the tensions.

The Media as Risk Culture Creator

One of the longest standing findings in mass communication research is the existence of the "sleeper effect"—or the human tendency to disassociate the source from the message. The bottom line on this research is that it's the message itself that remains memorable while individual evaluation of source credibility decays rapidly over time.

Until this point, this paper has focused exclusively on news accounts. What almost all Americans know about Chernobyl was brought to them via the news media. But, what American know about nuclear energy—or think they know about nuclear energy—comes from a variety of sources, some of them explicitly fictional. While there has been no specific scholarly research to test this assertion, if this long standing finding about the sleeper effect can be applied to risk, then what people know about risk through the mass media is a blend of the news, advertising for particular products, entertainment programming, including films, and a amalgam of other information sources—some of them mediated, others not. Given this understanding of how people put together their cognitive universes, it is not surprising that when engineers say nuclear energy, many Americans think "atomic bomb". As one scholar has noted, "When this analysis is complete,

without doubt, it will be found that the opposition to nuclear energy is in the nuclear, not the energy, and in the culture, not just the news (Shain, 1989, p. 160)." When the Children's Television Workshop teamed up with emergency management agencies to develop a hurricane warning campaign aimed at children, they first asked kids to tell CTW what *they* thought a hurricane was. The kids described the cyclone in *The Wizard of Oz*. And, CTW framed its campaign based on what the kids had learned from the movies, not what the hazards managers thought the children should have known.

In this sense, it is important to understand that neither journalists nor federal agencies control the vast majority of risk messages the public receives and may attend to. What many Americans know about the impact of oat bran on serum cholesterol probably comes from advertising, not news accounts. As many scholars have noted, such messages often interact in unpredictable ways; risk communicators would be wiser to try to use such synergy rather than deny or decry it. What is important to acknowledge is that the mass media, including the entertainment media, have an important impact on public understanding of risk and in creating the culture and climate that surrounds risk.

WHAT DOES THE PUBLIC LEARN FROM MEDIA ACCOUNTS

While the foregoing has emphasized predictable journalistic behavior, it is important to isolate, as much as possible, audience response to mediated messages. The main research findings in this area, some of which have already been noted, are:

- People appear to apply at least two distinct kinds of thinking to questions about risk. Experts operating within their own area of expertise employ what has been termed expert rationality, or a kind of thinking that takes into account the mathematical impact of base rates, probability, and to a much more limited extent, the capacity for interaction with other parts of complex systems. This is the sort of thinking that a doctor uses when writing a prescription; she understands that this particular drug works in a certain manner on many people, that it is likely to have this impact on you, and that certain other drugs you may be taking will probably interact with the medication in predictable ways. However, a medical doctor probably will not apply this sort of rationality when deciding whether to drive her car over flooded streets. In that situation, the doctor will rely on a lay heuristic—does it look like the event is under my control, what are the consequences if I make this attempt and fail, are the same things likely to happen to me as will happen to others in similar situations, etc. Most people, most of the time, think about risk in these lay terms. Even experts operating outside their own area of specialization will tend to think about risk the same way the "average" person would. Journalists, even those familiar with science and risk, will be operating from a "lay" perspective precisely because they know that the members of their various audiences also think this way.

- There is no single, homogeneous audience. Rather there are many audiences, with social, cultural and personal characteristics that will influence how individuals respond to risk communication messages. Response will never be monolithic.

- Audiences do appear to attend to a variety of warning measures, but the public does not always follow the advice. Prior experience with particular hazards or risks, family or community ties, etc. will have a significant impact on whether people decide to evacuate, build in a different area, stop smoking, or start eating more fruits and vegetables. Warning messages work best when they emanate from a variety of sources, not just the mass media or government press releases unless time is crucial.

- Audiences do appear to learn some facts about risk from mediates messages, but that knowledge is incomplete. For example, Missouri residents knew that they should be wary of a variety of food stuffs contaminated by flood waters and that there were ways to sanitize flooded homes. But translating that general awareness into specifics—throw out even canned food that has been in flood waters or that vinegar will not kill germs—was correct knowledge recalled by only a minority of those surveyed. Other studies have found that people can and do acquire and recall facts about hazards (Wilkins 1987) but that some activities that are appropriate for more than one hazard, for example storing water which is good practice in hurricane, tornado and earthquake country, is not readily generalized (Drabek 1986).

- When messages are salient, that is when audiences believe they will be immediately useful, many people can be expected to act on the appropriate advice. For example, people do call 800 numbers after news accounts, and people also do take suggested precautions if that information is made available to them. Such mobilizing information is generally appropriate during the warning or early event onset phase of a disaster. Further, risk communicators need to set realistic expectations about what constitutes success. It is unrealistic to expect that 100 or even 90 percent of those living in areas contaminated by radon will test their homes voluntarily. However, a campaign that persuades even a small minority, say 10 percent, to have their homes tested and take steps toward mitigation might well be considered successful, particularly if such "early innovators" tell their friends and neighbors and some of them follow suit. Such a pattern of adoption of innovation has been documented in the social scientific literature (Rogers 1983).

- Mass communication theory suggests that scholars evaluate the cumulative impact of messages rather than focusing on individual messages or even individual information campaigns. Such work, when it has been done in case study format, indicates that publics, when motivated, do become well informed, seek information from a variety of sources, are capable of complex reasoning and evaluating difficult trade offs. The mass media can and are helpful in this complex process, but they are only a single tool. Further, a great deal more evaluation research is needed on the risk communication process.

IF I DECIDE TO USE THE MASS MEDIA, HOW SHOULD I DO IT, AND WHAT SHOULD I SAY?

The mass media, particularly the news media, can be effective ways to reach large numbers of people with certain sorts of information. In using the media, the corps needs to keep the following in mind:

Understand what phase of the disaster/risk event you are in. At event onset, you can expect the media to function as a partner, relaying specific messages about evaluation, warnings, precautions, mobilizing acts, etc. Further, current research indicates that Americans most often tune to the broadcast media for such information. A printed press release is appropriate if that's the only thing you have time to prepare, but part of the planning process should be devoted to preparing messages that can be used on both radio and television and to developing a plan where the media become an active part of any emergency response system. If the question is less immediate, for example one of policy, news stories can do everything from helping to promote awareness of public meetings to exploring policy alternatives in some depth. Strongly motivated members of the public will use media accounts as a spring board for searching for more information. Many will use news stories to help them frame their own views. Regardless of intended or actual use, the inclusion of mobilizing information in media stories is essential if

you want to increase the chances that the message will be acted upon.

After event onset, however, the media will assume a much more critical stance as part of the evaluation function. The questions that journalists did not have time to ask or to think of at event onset—why did you adopt this course of action, why did you fail to anticipate this event, how much did all of this cost—can be readily anticipated. Be prepared to answer such questions honestly and with supporting documentation. Remember, journalists represent the lay public. A scientific or technical answer to a question that is essentially rooted in a fairness frame will be evaluated by journalists and their readers and viewers as non responsive and perhaps ethically culpatory.

Be aware of the demands on journalists themselves. Broadcasters work on short deadlines. Print reporters often have hours longer. A 1 p.m. press conference will be great for television or radio, but most newspapers will already have gone to press. Journalists do understand that specific events do not conform to media deadlines, but they are sensitive to the agency that prevaricates or withholds information. Further, television is a visual medium. Television reporters need pictures and particularly early in the event, those pictures may frame coverage for print journalists.

One way to provide television with pictures, and print reporters with solid information, is to make scientist/experts available to journalists as early in the risk communication process as possible. Not only does such access meet journalistic craft needs, but it tends to allay any suspicion that information is being withheld. However, experts need to be aware that journalists are not well trained in technical areas, including the mathematics of risk, and that many in the audience are even less well versed than the journalist. Experts should be told that they should anticipate questions about risk that are framed in a "lay heuristic". Further, they should be cautioned against answering such questions in an exclusively scientific/technical fashion. In addition, refusing to answer by noting "this is outside my area of expertise" is quite likely to be viewed as non-responsive and may fuel the suspicions of groups that have every good reason to be suspicious of those in power. Scientists/experts should be prepared to provide journalists, as well as many other members of the public, with a "this is the policy question and here are the potential solutions" sort of frame. Even with access, scientist/expert sources should be cautioned that their answers will seldom dominate news accounts. Other voices will be heard, and under the new risk communication paradigm, this is a desired outcome.

In times of genuine emergency, scientist/experts can take a tip from Neil Frank, former head of the National Weather Service in Miami. During hurricane season, Frank invited journalists and their cameras into his small cubical where all could see and photograph the visual displays of potential storm tracks and listen to Frank explain why evacuation was or was not necessary in this instance. Frank was astute enough to make partners of journalists for reasons of public safety; it was a partnership that served all.

However, emergency managers need to be aware that even a user friendly approach to journalists will not completely mitigate critical accounts. As indicated earlier in this paper, journalists themselves tend to report areas of scientific controversy as a battle between dueling experts. Many groups have learned how to use, and some would argue manipulate, the mass media. Further, the profession itself carries with it a host of restrictions, everything from time and space limitations to the training of individual reporters, to the capacity of the audience understand and absorb what is often complicated and contradictory information. Feelings often will be hurt; sometimes careers will be damaged as well as

made. Journalists, just like federal and state agencies, can and do make mistakes. The public is properly skeptical of media accounts, and many people are savvy enough to distinguish between good and mediocre journalistic work.

The mass media are merely one tool in the risk communication process. They are an important tool, one that those familiar with them only as readers and viewers often tend to underestimate. The media can be used most effectively as one element in an overall risk communication effort. If this is the goal, then journalistic accounts can allow a democratic society to have better, more informed fights, about the choices surrounding issues of risk. In that conversation, everyone, including agencies, stands to benefit.

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APPENDIX F

RISK PERCEPTION, COMMUNICATION, AND COMMUNITY RELATIONS

RISK PERCEPTION, COMMUNICATION, AND COMMUNITY RELATIONS

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INTRODUCTION

Over the past two decades one of the most dramatic phenomenon on the social scene has been the rise of broad, public involvement in decision making about complex technologies, including those that protect society from natural hazards such as floods. Spawned by national legislation that required proponents to assess environmental impacts of their proposed projects, public involvement in regulation of technology, including siting decisions, has become a pandemic feature of modern risk management.

As a consequence, the public has greater opportunity than ever before to be aware of both risk managers and the workings of their institutions, largely through increased media scrutiny of technology and its failures (e.g., Singer & Endreny, 1993). Thus, to be a successful risk manager, or risk management institution, is to understand the issues that the public deems important and the mechanisms by which public participation in risk management, including decisions about technologies, can be undertaken in a productive and (relatively) uncontentious manner. To do otherwise, is to invite disaster in the form of immense social costs associated with projects that have failed because the public will not provide its support via its role as political constituency or host community.

Arguably, the most salient example of a catastrophic failure of risk management is embodied in the effort to establish a permanent repository site for high-level nuclear waste in the United States at Yucca Mountain, Nevada. Though experts strongly agree that the technical problems can be resolved and the risks effectively managed, the process has become stalled, embroiled in a political controversy fueled by public discontent over the impacts such a project would have on the social and economic future of their state. The *post mortem* on the US. Department of Energy's proposal for Yucca Mountain reveals a stark and disastrous disregard on behalf of the project's proponents for the sentiments of the public who would be impacted by the project, leading to a stalemate in which public distrust overshadows expert proclamations about the proposed repository's safety (Flynn, Kasperson, Kunreuther, & Slovic, 1992). Though the problems at Yucca Mountain may have received such widespread attention because of the sheer enormity of the project itself, they also reflect a general set of difficulties faced by virtually all proponents of projects that, in one way or another, require the analysis, communication, and management of risks to which the public is exposed.

Public empowerment in risk management decisions poses strong challenges to risk communication for several reasons. First, the technical issues inherent in risk analysis and assessment are well beyond the grasp of most members of the public. Inherently couched in quantitative language, risk as conceptualized by the technical community bears relatively little resemblance to the conceptualization of risk that is held by lay people.

Second, the questions that risk analysis and assessment seek to answer are often very different from those for which the public seeks answers. For example, while risk analysis provides answers about the distribution of probabilities associated with a given consequence, the public typically wants to know whether or not they are safe.

Third, the fact of public involvement presupposes that the public wants to be involved and will be a willing party in risk management decisions. Though there is a great deal of evidence that some members of the public hold strong opinions about technological issues and want to exert an influence upon risk management decisions, other members of the public may simply prefer to trust that experts will "handle things" so that they can turn their attention to those concerns that are more central to their lives and that dominate their daily worries (MacGregor, 1991). Disputes between project proponents and community

activists, or between risk analysts over technical issues, can signal people that trusting experts (or their institutions) may be an imprudent thing to do, thereby causing them to redirect their attention and concern to a project or issue that would otherwise have gone unnoticed. The "enlightened" project proponent, therefore, needs to be aware of how public values about technology are framed, their perceptions of institutional credibility and trust, the agendas of differing "publics" that motivate their participation in risk debates, and the uncertainties that surround the effectiveness of different participation processes (Kasperson, 1986).

Given the importance of the public in decisions about large-scale technological projects, maintaining a strong and cooperative relationship between risk experts and the public is of tremendous value. An important tenet of risk management is that the relationship between risk experts and the public at large is well served by taking steps to insure that the communication of technical risk is done to the highest standards of quality. To that end, a wealth of research in risk communication has served as a basis for guidelines that can be followed by project proponents to insure that the process and content of risk communication meet certain benchmarks, adherence to which offers, by definition, the best hope that conflicts and disagreements will be avoided, or at least minimized. Very little of this basic advice has changed over the years, and excellent overviews of techniques and issues can be found in the following sources (see reference section for complete citations):

- Covello, von Winterfeldt, & Slovic (1986);
- Covello, Sandman, & Slovic (1988);
- National Research Council (1989).

What has changed is the emphasis on the need of project proponents and the technical analysis professions to understanding the broader social and psychological context within which they and their projects are evaluated by members of the public. The goal of this paper is to present and overview of that context from the perspective of informing the use of risk communication, including what risk communication can reasonably be expected to accomplish in terms of facilitating decisions about project development that include members of the public.

TWO PERSPECTIVES ON RISK COMMUNICATION

We begin by contrasting two viewpoints about risk communication. The first viewpoint casts risk communication as a matter of form and content. Its essential goals are to provide technical information about risks, in an understandable form, with the purpose of achieving public reassurance and confidence in the risk management process. In many cases, there is an unstated intention to convince the public that risks are small, or smaller than they are perceived to be. This is very much an expert viewpoint on the mission of risk communication, with heavy emphasis on the technical content of risk messages. To its credit, it seeks to involve the public in an ostensibly open and two-way dialogue about risk, and strongly encourages risk communicators to be sensitive to public concerns. However, its tenor is predominantly educational, and its prescription for openness generally does not extend to empowering the public in risk management decisions. Thus, risk communication of this type can do little to change public participation in the risk management process, and, therefore, virtually nothing to modify the power and control imbalance that exists between the technical community and the public at large.

In the second viewpoint, risk communication is part of the process of managing risks. Most, if not all, of the form and content prescribed for good risk communication are what the public typically expects would be done in a normal and appropriate process

for managing anything in society. Thus, risk communication practiced to its highest published standards can, at best, *confirm* for the public what they already believe should be done. Risk communication of exceptional quality from a technical, professional perspective is not necessarily meritorious from a public perspective, but is a *hygienic* factor that can help maintain the perceived integrity of an organization and its representatives but can do relatively little to improve it.

This model of the relationship between risk management and risk communication is based on research in human judgment that has found that people hold norms and expectations relating to concepts such as honesty and trust, and these norms are powerful determinants of how objects and events are perceived (e.g., Gidron, Koehler, & Tversky, 1993). Thus, risk communication is perceived by the public in terms of a general process model that includes expectations and theories about how management of societal risks should be carried out. The expectancy theory sets limits on the potential effectiveness of risk communication to foster and promote public trust in risk managers. In addition, it strongly indicates a need to understand how public definitions of risk differ from those of technical experts, and how those definitions lead the public to ask questions of project proponents that are less related to technical issues about risk and more related to project development and management issues that may have little or nothing to do with technical risk assessment.

PUBLIC DEFINITIONS OF RISK

Risk is one of the oldest concepts in human society, evident by its presence in the Indo-European roots of modern language. The Latin derivation, *resecare,* is formed from the prefix *re,* meaning "against" and *secare,* "to cut." To cut against—to cut off—the part that is cut off or lost: the risk. In one way or another, risk identifies the potential for suffering, harm or loss, and signals danger and uncertainty. For contemporary risk analysts, technical definitions of risk are comprised of essentially two components: a potential loss or consequence and a probability or likelihood that the loss would occur. This definition of risk provides a convenient two-parameter framework for analyzing hazards, and making explicit the relative advantages and disadvantages of various project designs and means of reducing risk.

For the public, however, risk is defined in terms of factors that relate both to a quantitative and technical definition of risk as well as to the social and psychological context within which technologies, their risks and their benefits are experienced. One framework for conceptualizing a public definition of risk, the *psychometric paradigm*, has grown out of work which uses psychophysical scaling and multivariate analysis techniques to produce representations or cognitive maps of risk attitudes and perceptions. A second, and more recent, approach is based on advances in cognitive psychology that focus more directly on the content of risk perceptions and attempt to develop comparative *mental models* of expert and public risk perception.

The Psychometric Paradigm of Risk Perception

The psychometric paradigm (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, Fischhoff, & Lichtenstein, 1984), has been used to characterize societal risks in general as well as to identify perceptions of risks in specific contexts such as automobile safety (MacGregor & Slovic, 1989; Slovic, MacGregor, & Kraus, 1987). Psychometric analyses of risk are typically done by asking respondents, generally members of the public or of some specific group of interest, to evaluate a number of different technologies, activities, or substances in terms of characteristics that relate to the social context of risk, dreadedness of consequences, catastrophic

nature of consequences, equitability of risk/benefit distributions, and need for regulation. The resulting judgments are then used to develop a characterization of the set of risks in terms of two general, independent factors comprised of the larger set of judgment scales. Figure 1 is an example of a psychometric analysis done on 81 hazards (Slovic, 1987).

Results like those shown in Figure 1 are generally taken as evidence of why some risks, such as nuclear risks and chemical risks, draw much more concern from the public (or a different kind of concern) than would appear to be due given the results of technical analyses. Extreme concerns are generally expressed by the public for risks that fall in the upper right hand quadrant of Figure 1. These are risks that are generally seen as uncontrollable, dreaded, catastrophic, involuntary, inequitable and not readily observable. These risks are also ones for which the public overestimates the number of fatalities, and expresses a greater desire regulation.

There are lessons for project proponents that can be gleaned from results like those presented in Figure 1. First, public perceptions of risk are based on two general factors that can be thought of as comprised of subordinate characteristics, most of which are fundamental evaluations that people apply to other life events and contexts, and to which people are highly sensitive, such as the loss of control, involuntariness, catastrophic events, and unfairly bearing risks for which someone else receives the benefits. Even technical risk experts, when evaluating risks outside of their area of technical expertise, are sensitive to these concerns, and may be similar to the public in how they respond to risks with which they have relatively little familiarity. Second, social context dominates quantitative risk assessments as a basis for public assessments of risk. Therefore, risk communication that focuses heavily on technical information is somewhat unlikely to have a broad, positive influence on public attitudes, unless it answers specific questions about how contextual concerns can be managed, such as improving controllability of exposure or addressing inequities in risk/benefit distributions. Finally, it is critical for project proponents to recognize that most members of the public attempt, in one way or another, to comprehend the complexities of a technological project, given their base of knowledge and understanding, as well as their experience with other technologies. Unlike technical experts who have intellectual and technical tools at their disposal, the public for the most part must use simplifying mental strategies to manage what would otherwise be an unassailable task.

Mental Models of Risk

While the psychometric paradigm has provided a useful framework for conceptualizing the social contextual elements that influence risk perceptions, it provides a less detailed picture of how people reason about specific risks and how new information about a given risk will be integrated into what they already know or perceive. A more recent strand of research that has evolved along these lines has sought to improve our understanding of the *mental models* that people use to reason and make inferences about risks. A mental model is a construct used to explain the system of knowledge, attitudes, and beliefs people hold about a particular domain and that they use to answer questions, explain events, or make predictions (e.g., Gentner & Stevens, 1983; Johnson-Laird, 1983; Johnson-Laird & Byrne, 1991). In essence, mental model research as applied to risk perception compares the cognitions people hold about a risk with the models of technical experts. For example, Maharik & Fischhoff (1992) used a mental model approach to contrast expert and lay activist perceptions of the risks and benefits of using nuclear energy sources in space, such as to power interplanetary space vehicles. They found that the activist model of nuclear risk contained many of the same concepts as that of experts, but the concepts were poorly (or not)

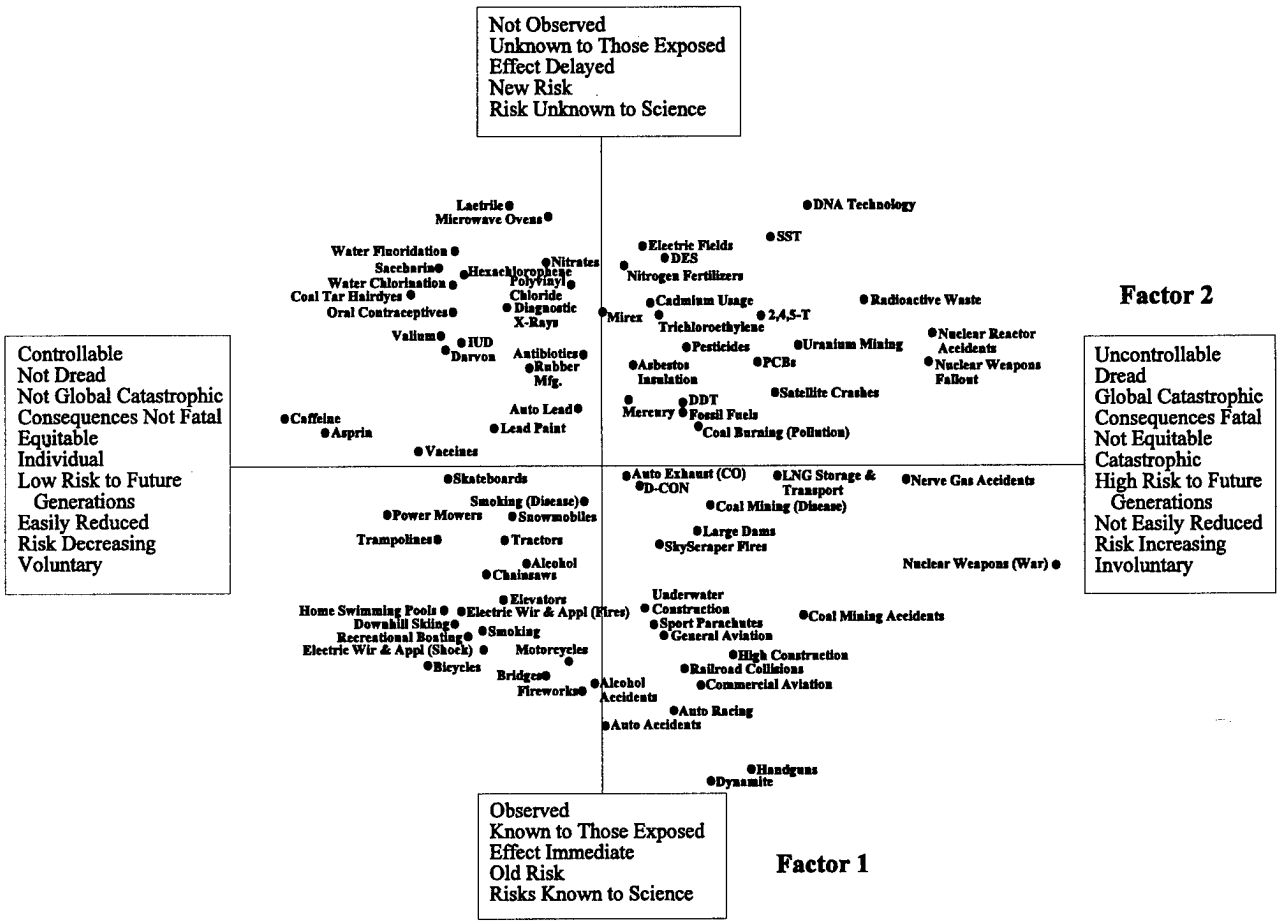

Figure F-1. Location of 81 Hazards on Factors 1 and 2 derived from the interrelationships among 15 risk characteristics. Each factor is made up of a combination of characteristics. Source: redrawn from Slovic (1987).

integrated into an overarching process model of how failure of an aerospace system leads to individual radiation exposure and health effects. Many of the concepts in the expert model were simply absent from the lay model. Significantly, the lay model did not include mention of any benefits of nuclear power in space (though people were directly asked the question), and none of the lay subjects stated explicitly that nuclear energy was the only way to accomplish extended, deep space missions.

MacGregor, Slovic, & Morgan (in press) used the mental model and psychometric paradigms to evaluate a set of specific risk communication materials developed to inform the public about the potential health risks of exposure to power-frequency electromagnetic fields (EMF). The risk communication materials were in the form of a 16-page brochure, titled *Electric and Magnetic Fields from 60 Hz Electric Power: Briefly, what do we know about possible health risks?*, developed at Carnegie

Melon University under the sponsorship of the Electric Power Research Institute. The brochure was adapted from a larger booklet—over 100,000 copies of the booklet were distributed to interested individuals, other researchers, and various organizations in the electric power industry including utilities. The content of the booklet has come to form the information kernel of the public information programs on EMF health risks of many local utilities. The brochure was developed as a general introduction to EMF and its potential health risks, with an orientation toward the science of EMF health risks research. As such, it is an over-the-shoulder look at the scientific evidence on EMF health effects, including considerable discussion of the scientific uncertainty surrounding existing research. As part of this discussion, the text mentioned appliances and electrical devices found in the home or office. X-rays and microwaves are compared and contrasted with EMF as sources of radiation, and the effects of radiation on DNA and cell tissues are discussed. In its review of research on health effects, various biological mechanisms and health disorders are mentioned: including heart rate, reaction time, brain cancer, birth defects, chronic depression and neurological disorders. Thus, the risk communication brochure presented a technical and scientific look at a particular health and safety risk.

The results of the evaluation showed that lay people reading the brochure were highly sensitized to a range of potential health effects of EMF, even though the brochure explicitly stated that there was no evidence that EMF's had such an effect (e.g., chronic depression). The model that subjects appeared to use to integrate the information in the brochure was based on the notion of interference; whereby EMF's were seen as interfering with the natural electrical activity of the body much in the same way as a light dimmer might interfere with a radio or cordless telephone. The interference model provided subjects a powerful framework within which to reason about a whole range of health effects for which specific causes are unknown, but could conveniently be inferred from the basic principles of the model (e.g., mental disorders, cancer, heart attacks). Though the brochure was careful to point out that no firm conclusions can be drawn at this time about the effects of EMF's on human health and that scientists do not know of the mechanism relating EMF exposure to health anomalies, lay people appear to have a model of their own that they regard as a powerful and useful tool.

Though only a handful of studies presently exist that have explored the potential of the mental model paradigm in understanding more about risk perception and communication, it is clear that focused work along these lines can yield insights into how risk communication can be improved. If the factual elements of people's mental models are in error, they can be addressed directly by information. If people lack an overarching understanding of how risks evolve, they can be given more understanding of process. If benefits are absent from their mental models, then more balanced communication can be developed. If their mental models lead them to ask questions, then risk communication can move away from information-based strategies and more toward processes that put them in closer, direct contact with project proponents.

WORLDVIEWS GUIDE INTERPRETATION OF COMPLEX INFORMATION

Despite the best efforts of risk communicators to employ techniques that aim to simplify a complex information field, the meaning that people derive from risk communication will often be influenced by strategies that they use to simplify what they have been told.

A powerful simplifying strategy that plays an important role in risk perception comes from work on worldviews. Worldviews are general attitudes or beliefs that predispose people toward different

outlooks and have an influence over their judgments about complex risk issues (Buss, Craik & Dake, 1986; Cotgrove, 1982; Dake, 1991; Jasper, 1990). Dake (1991) has conceptualized worldviews as "orienting dispositions," because of their role in guiding people's responses in complex situations. Some of the worldviews identified to date are listed below, along with representative attitude statements:

- Fatalism (e.g., "I feel I have very little control over risks to my health")
- Hierarchy (e.g., "Decisions about health risks should be left to the experts")
- Individualism (e.g., "In a fair system, people with more ability should earn more")
- Egalitarianism (e.g., "If people were treated more equally, we would have fewer problems")
- Technological enthusiasm (e.g., "A high technology society is important for improving our health and social well-being")
- Cornucopian (e.g., "The earth is abundant and robust")
- Catastrophist (e.g., "The earth is limited and fragile")

So powerful are worldviews for helping people manage an otherwise complex environment, that even expert judgment is influenced by them. For example, Slovic, Malmfors, and Neil (1993) found evidence that some worldviews are predictive of toxicologists' scientific judgments concerning the carcinogenicity of a chemical tested in a number of animal studies. A group of 125 members of the European Society of Toxicologists completed a survey that asked them to respond to a wide range of attitudinal items concerning chemical risks, as well as attitudinal statements relating to a number of worldview dimensions. Part of the survey included a summary description of four animal tests conducted using a chemical named only as Chemical B. The summaries for each of the four studies included exposure concentrations, body weights of the animals, survival rates, neoplastic and non-neoplastic effects, and genetic effects (based upon *in vitro* tests). The chemical and test data were real, taken from the files of the National Toxicology Program. Respondents were asked to judge the degree to which the four studies provided evidence of carcinogenic activity in these animals.

These judgments of carcinogenicity were found to be related to scientists' worldviews. For example, the following item assessed attitudes toward economic growth: "Continued economic growth is necessary to improve our quality of life." Toxicologists who disagreed with this item were approximately 12 times more likely to judge that the studies provided evidence for the carcinogenicity of Chemical B than to judge Chemical B as noncarcinogenic (53.3% vs. 4.4%). However, toxicologists who agreed with the item were only slightly more likely to judge the studies as indicating carcinogenicity than not (31.4% vs. 21.6%).

PERCEPTIONS OF RISK ANALYSIS AS A DECISION-MAKING APPROACH

Project development involves a complex set of processes that generally includes a number of stages, activities, institutions and individuals. For example, consider the management of risks from carcinogenic or toxic chemicals. The magnitude and the probability of the risk is determined by a quantitative risk assessment, a process that itself contains many subanalyses including determination of a dose-response relationship and pathways by which exposure occurs. Regulatory agencies are involved in setting standards about when such chemicals can be used, how they should be transported and stored, how

workers should be protected, and what should be done with chemical wastes. Industries are involved in insuring that regulatory standards are met, that the chemicals are not used unwisely, and that accidents don't occur.

However, the public typically receives little more than a glimpse of how risk analysis and management is actually carried out. For the most part (and for most technological risks) risk management occurs outside of the scope of public view. While the public is exposed to events involving technological hazards both directly and through the media, these experiences contain little or no information about the processes by which risks are managed. Indeed, from the public's perspective, risk management is very much a matter of implied trust.

How are risk management processes perceived by the public in terms of their adequacy, acceptability, and trustworthiness? To date, we have very little empirical work that directly addresses this question. One study we do have, however, comes from MacGregor & Slovic (1986). They studied lay perceptions of risk assessment applied in the context of risk management decision making. The context for their study was a proposed safety improvement to two different consumer products: motor vehicles and pharmaceutical drugs. Subjects were given one of four different risk assessments used by a manufacturer to decide or not to make a change in a product that would improve its safety. One of the methods was based on cost-benefit analysis, and specifically calculated the dollar value of lives lost if product safety was not improved. Two of the methods were based on risk analysis, one version indicating the numbers of lives lost without safety improvement, and a second version indicating the change in probability of mortality for a single individual. A final version provided a brief description of standard practices for managing this particular risk in the industry, without a quantitative analysis. Each of the methods was evaluated on a set of scales relating to understandability, completeness, logic of reasoning, sensitivity to those effected by the decision, moral and ethical considerations, and a judgment of the overall acceptability of the risk management approach. The scales and their wording are shown in Table F-1.

The results indicated that the acceptability of risk assessment was related to two general, independent factors. One factor was "logical soundness" where methods that were understandable, logical, and handle uncertainties well were judged more acceptable. The second was a "sensitivity" factor where methods that were sensitive to those effected by risk management and that incorporated moral and ethical considerations were deemed more acceptable. While the analytic approaches tended to score relatively high on the logical soundness dimension, they faired less well on the sensitivity dimension.

The MacGregor and Slovic results suggest that at least two broad dimensions are of importance to lay people in their perceptions of at least some aspects of risk assessment. One dimension is comprised of perceptions of the logic, completeness, understandability and apparent amount of effort that goes in to risk analysis. The second dimension is comprised of judgments about humaneness, the degree to which ethical and moral considerations are addressed and risk analysis is sensitive to the people exposed to risks.

THE ROLE OF BENEFIT ASSESSMENTS IN TECHNOLOGICAL PERCEPTIONS

One of the principal reasons that risk communication is so difficult is that it is about risk. Risk is not an inherently pleasing topic for people. It evokes a great range of concerns and fears, few of which are dampened by more information.

The focus on risk communication is, in many ways, a misplaced focus if the goal is to communicate about a project or a technology. All technologies

TABLE F-1

JUDGMENT SCALES FOR RISK ASSESSMENT METHODS

Understanding	How well do you feel you understand the method as presented?
Completeness	How complete to you feel the method was; to what extent did it consider the factors you feel relevant?
Logic and reasoning	To what extent does the reasoning in the method seem logically sound?
Uncertainties	To what extent does the method seem to take into account uncertainties about values, information, and consequences?
Expedience	To what extent does the method seem to require effort on the part of the decision maker?
Sensitivity	To what extent does the method seem sensitive to the wishes of the individuals affected by the decision?
Moral and ethical considerations	To what extent does the method consider what is right and wrong from a moral standpoint?
Acceptability	To what extent does the method of making a decision seem generally acceptable to you?
Appropriateness	How appropriate did the method of making a decision seem in this case?

the public may be unaware of many of the benefits associated with some types of projects and technologies, particularly those that have a beneficial impact distributed over a large number of people or over a long period of time.

Conceivably, one of the reasons that the public has become so sensitized to risk issues is because science has evolved a much richer framework for conceptualizing risk than for conceptualizing benefit. For example, while we have a relatively detailed framework for characterizing public perceptions of risk, we have no comparable framework for characterizing benefits. The effort that has gone into risk research has, in effect, framed most societal decisions about technology in terms of risk-related concepts. From this perspective, the public's apparent concerns about risk are only a reflection of how technological decisions have been portrayed to them.

RISK COMMUNICATION AND THE CONTEXT OF TRUST

Social relationships of all types, including risk management, rely heavily on trust. Indeed, provide some form of benefit, even if that benefit is the reduction of a pre-existing risk. This fact is so fundamental that it is often overlooked by project proponents, many of whom spend a great deal of time and effort preparing polished portrayals of risk without recognizing that their project was originally intended to provide a benefit.

Research has shown that there is an inverse relationship between risks and benefits when risks are judged to be relatively high, benefits are judged to be relatively low (Alhakami & Slovic, in press; Gregory & Mendelsohn, 1993; Slovic, Kraus, Lappe, Letzel & Malmfors, 1989; Fischhoff, Slovic, Lichtenstein,

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Though it is not yet clear exactly how benefit and risk perceptions become related to one another, it is clear that they are not assessed independently. This is a significant finding for risk communication, for it suggests that risk communication may, in some circumstances, do a disservice to a project by emphasizing only one element of its character. Arguably, an informed public should be one capable of making reasoned decisions about technology (NRC, 1989); to do so requires making tradeoffs that require an understanding of both what is to be gained and what is to be lost for each alternative.

A useful, and perhaps more realistic, perspective is to adopt a model of technological communication that casts a given project in terms of its intended goals and outcomes as well as the risks associated with each outcome. It is not reasonable to assume that the public will bring to risk communication (either at meetings or when reading materials) their knowledge about the benefits of a project under consideration. Indeed, much of the contentiousness that has been observed in the risk-management arena has been attributed to a climate of distrust that exists between the public, industry, and risk-management professionals (e.g., Slovic, 1993; Slovic, Flynn, & Layman, 1991). Trust has been discussed extensively as an important factor that contributes significantly to risk communication and to the overall success of risk management. These discussions have emphasized two important qualities of trust its asymmetry and its fragility. Trust is asymmetrical in the sense that it is more easily destroyed than it is created. Events that have a negative impact on trust have a stronger impact than events that have a positive impact on trust. Overcoming the effects of negative events on trust is tremendously difficult, if not impossible. This asymmetry contributes to the fragility of trust. A trusting relationship with the public can be undone by as little as a single instance or event that signals impropriety, mismanagement or unreliability.

Though project proponents are frequently advised on the importance of trust and to develop trusting relationships with the public, that advice is seldom given substance with concrete recommendations or specific guides to action. More often, trust (or more appropriately, distrust) is provided as an explanation for why project proponents have gotten into trouble with the public, or why a given project or technology has failed to achieve broad public support. It may be more useful, therefore, to go somewhat beyond the existing base of research to identify potential steps that can be taken to help maintain whatever level of trust exists between a project proponent and the public with which it is involved.

Effects of Risk Uncertainty on Perceptions of Trust

One of the questions that constantly plagues risk communicators is how to realistically portray a

to introduce into their messages. While risk communicators are frequently advised to tailor their information to the needs and level of interest of their audiences, the specifics of how to do that are often left undefined.

Some professionals and advisory bodies have suggested that a range of uncertainties better communicates the realities of risk. For example, the Carnegie Commission on Science, Technology, and Government said in 1993 that "communicating a range of doses provides citizens with a more realistic description of a hazard and hence results in more informed choices when the range of risks to which one is exposed is considered" (*Risk and the environment*, 1993, p. 87). However, audiences often want answers to questions that are different from those that technical analysis is prepared to address. Most imperative among these is whether something is safe. In this light, the introduction of uncertainty into risk communications may serve to confuse an audience or suggest that risk management is somehow deficient or incompetent.

Evidence of such an effect comes from a recent study by Johnson & Slovic (1994). They studied perceptions of a environmental health risks presented to lay respondents as newspaper vignettes. The vignettes described a report from the US. EPA on the possibility of cancer risks to a community from one of two sources, either a toxic chemical in the water supply or a naturally occurring radioactive gas. Within the vignettes, technical estimates of risk were varied as to degree of uncertainty by presenting them as either point values or as ranges. Johnson & Slovic found that while people's perceptions of risk were influenced by formative properties of risk communication (i.e., point values versus ranges; numeric vs. graphic presentation), other factors associated with perceptions of agency trustworthiness, honesty, and competence played a much more significant role. Furthermore, when technical risks were presented with greater uncertainty (as a range of estimates), an *increase* in the perceived honesty of the agency was accompanied by a *decrease* in their perceived competence.

Results such as these offer a mixed bag. In part, they validate the body of research in risk communication that affirms its effectiveness by finding that people's perceptions of risk are sensitive to variations in the form and content of risk communication. However, risk communication that also conveys technical uncertainty interacts with perceptions of the competence and trustworthiness of risk management. It is not unreasonable to conclude that when a risk management institution is distrusted, increasing the depth of technical communication by, for example, introducing greater uncertainty into technical risk estimates will only serve to make matters worse. In these circumstances, risk communicators may be wise to retreat from pushing their message along technical lines, and direct their efforts instead at improving the public's confidence in the ability of their institutions to perform competent and trustworthy risk management.

Trust and Personalized Risk Communication

Risk communication has come to encompass such a broad range of methods and goals that it can, in principle, subsume everything from the simplest of product warnings to highly individualized contacts with key activists in a potential host community for a project. Trust, as a property of public perceptions of technology, is a quality of human relationships, either between individual representatives of a proposed project and members of a community, or between the public at large and an institution. A critical characteristic of *distrust* is that, once initiated, it tends to inhibit the kinds of personal contacts and experience that are necessary to overcome distrust. In a climate of distrust, it is sometimes perceived by a project proponent as easier to rely on forms of risk communication that doesn't involve the tough, face-to-face contact with the public that often draws

criticism and raises emotional energies to uncomfortable levels.

There are several ways that risk communication can become *impersonalized.* One way is through the overuse of printed matter, particularly when no author or named individual who can be contacted is given. While there are many circumstances in which brochures, booklets, and the like are appropriate and suitable, they should never be a substitute for direct contact between the public and a project proponent. Indeed, even for highly trusted professions, such as medical doctors, people's trust is much higher for their personal physician (whom they know) than for medical professionals in general, or for hospitals. The importance of a named, responsible, and accountable individual as the proponent of a project cannot be overstated. Diffusion of responsibility for a project from individuals to an institution at large can work against establishing a trusting relationship with the public.

THE ROLE OF PROCESS IN PERCEPTIONS OF RISK AND RISK MANAGEMENT

Though no one has yet provided a solid prescription for trouble-free project siting, the Yucca Mountain project and others like it that have become stalled in the heat of public contentiousness have led to the development of recommendations that may be helpful in avoiding some future problems. Virtually all of them involve, in one way or another, the creation of a highly participatory environment in which the public is empowered to exercise a role similar (or the same) to that available to them by virtue of the democratic institutions that characterize modern western societies, including a clear mandate for project sitings to be undertaken on a voluntary basis (e.g., Flynn, Kasperson, Kunreuther & Slovic, 1992; Slovic, 1993).

Public empowerment in risk management decisions poses strong challenges to risk communication, largely because the process of communication shifts from a didactic, one-way process to a shared process in which the form of a project may change in light of public values. The "enlightened" risk communicator, therefore, needs to be aware of how public values about technology are framed, their perceptions of institutional credibility and trust, the agendas of differing publics that motivate their participation in risk debates, and the uncertainties that surround the effectiveness of different participation processes (Kasperson, 1986).

The need for effective participatory strategies has led to guidelines such as the Facility Siting Credo, a framework for facility siting that was developed during a National Facility Siting Workshop in 1990. The Credo makes a distinction between a set of procedural steps that help create a participatory environment conducive to the development of trust and consensus building, and a set of desired outcomes that identify the goal states the procedures should be directed toward (Kunreuther, Fitzgerald, & Aarts, 1993). Table F-2 summarizes the principal elements of the Credo.

An evaluation of the effectiveness of the Credo was done by surveying 29 waste facility siting cases, both successful and unsuccessful, across the United States and Canada. The results revealed that successful sitings tended to be those in which an atmosphere of trust was achieved between the proponent and the host community, and the proposed facility was seen by the community as appropriate and meeting its needs (Kunreuther, Fitzgerald, & Aarts, 1993). However, it remains to be seen how well the Credo fares in other siting contexts other than noxious wastes. Many of the sitings studied by Kunreuther et al. were for projects having high benefit to a local community, such as a municipal land fill. Arguably, these projects are more easily justified to community members because the benefits

are almost exclusively distributed locally. On the other hand, projects such as dams and power generation facilities (e.g., natural gas cogeneration) fill much larger needs that those of a local community, and a significant disparity exists between their risk and benefit distributions.

TABLE F-2
PRINCIPLE ELEMENTS OF THE CREDO

Procedural steps

- Institute a broad-based participatory process
- Seek consensus
- Work to develop trust
- Seek acceptable sites through a volunteer process
- Consider a competitive siting process
- Set realistic timetables
- Keep multiple options open at all times

Desired outcomes

- Achieve agreement that the status quo is unacceptable
- Choose the solution that best addresses the problem
- Guarantee that stringent safety standards will be met
- Fully address all negative aspects of the facility
- Make the host community better off
- Use contingent agreements
- Work for geographic fairness

Nonetheless, the Credo points the way to the direction that project proponents and risk managers need to take if their goal is to achieve some measure of public contentment with how facilities are sited. It is fair to conclude that the future of facility siting and risk management will involve a greater degree of public participation than it has in the past. In all likelihood, that involvement can not come too early in the project development cycle, even to the extent of guiding technical decisions about how a facility will be designed and constructed.

CONCLUSIONS AND RECOMMENDATIONS

Risk managers and risk management institutions are faced with an ever-increasing set of challenges to fostering good relationships with the public. Without a doubt, risk communication will continue to play a vital and central role in risk management, if for no other reason than people will always want to know something about "the facts" of the risks to which they are exposed. Technical risk assessment is, for the foreseeable future, the means by which those facts become known to science. The state of that science for any given hazard will always be of interest to the public, and to one of its principal messengers, the media.

But, risk communication is no magic bullet. It is but a relatively small part of a larger social process by which risks are decided on and managed, and by which technologies come to be either rejected or accepted. The following conclusions and caveats may be of help in gauging what risk communication can reasonably accomplish, and where else one's energies might be expended more productively.

- *Higher quality public involvement.* The research clearly shows that public involvement is a necessary part of risk management. However, the research is less clear on the specifics of what that involvement should look like. Though some researchers recommend *greater* public involvement in risk management decisions, it is less certain that more is necessarily better. It is perhaps more appropriate to conclude that public involvement of high quality is more important than, for example, involving more

members of the public, or involving the public more deeply in issues that they are poorly prepared to grasp. There is a risk in taking the tack of involving the public by allowing them to cathart and express their anger and rage, but doing very little to accommodate their views or change how things are done. This form of involvement is perhaps better characterized as indulging the public, which sometimes happens under the guises of involving the public more.

High quality public involvement has not yet been well defined. Risk management institutions must develop guidelines for high quality public involvement. These guidelines should be based on definitions of what is wanted from the public, and how their viewpoints will be incorporated into risk management decisions. Are there technical decisions where public values would be relevant? Can the public be helpful in defining approaches for relating to their own constituency? Is there training and education that the public needs to be an active, valued, and respected participant in risk management?

- *Earlier involvement of the public in the project development cycle.* Very often, the difficulties that project proponents face in the public arena are brought about because those impacted by a project are the last to know of its existence. Project development is a complex and risky process. For project developers, the road that leads from an idea to a construction permit is a long and hazardous one. Only a very small number of the projects that are considered actually make it to the point of filing an application with a regulatory agency. Usually by the time an application is filed, many decisions have been made that are very difficult to reverse, making it virtually impossible for a proponent to incorporate the public's input. Project proponents need better advice on how to involve the public earlier in the development cycle. And, risk management institutions need better guidance on how they can give that advice in a responsible way that is sensitive both to the needs of the public and to the constraints and problems faced by the proponents.

- *Greater reliance on volunteer communities.* For the public to be a willing partner in technology, it needs to know what is in it for them. For a project to be of true benefit to a community, it must fit within their own framework of goal and objectives, and not just those of project developers. Project proponents should be encouraged to strive for a partnership with host communities. The first step in establishing that partnership is a recognition of the critical importance of voluntariness in decisions about technology. The normal project development process can seem to community members as imposing the results of decisions made by others upon them, particularly when public involvement does not occur until far downstream from project planning. By working toward voluntary participation in project development, proponents may actually reduce the risks that a project will run into trouble that can result in costly delays or even more costly abandonment.

- *Increase public trust in risk management or develop processes that don't rely on trust.* We are currently at an important junction in the evolution of socially accountable risk management. All the research to date on the failures of risk management point strongly to the erosion of trust both in government and in many of our social institutions as an important causal factor in the conflicts that exist between the community of risk experts and the public. At this juncture, we need to move forward in one of two directions. One path that has been advocated is to work toward increasing public trust in risk management. The previous sections discussed research that has been conducted in this spirit. While it is much too soon to express either optimism or pessimism about the likely success of this strategy, it is a significantly challenging problem that at the moment appears to have no easy answers.

A second path leads in the direction of developing risk management processes that do not rely on trust,

or rely on it only minimally. Though it is seldom acknowledged explicitly, many of the steps currently being taken by government and industry to involve the public through community advisory panels and the like are, in effect, establishing layers of oversight such that the checks-and-balances principles inherent in democratic governments are instituted within technological risk management. This may be a fruitful avenue to pursue, and research along these lines is certainly needed.

- *Increased accountability of the public for their role in risk management.* Ideally, the public and risk professionals would work with each other in a climate of mutual respect. One conclusion that can be drawn from the body of social science research that has identified some of the sources of public discontent is that the public holds a viewpoint that mimics the complaint of Rodney Dangerfield, "I don't get no respect." However, respect is a two-way street and doesn't come without a demonstration of one's worthiness. If the public wants greater respect from technical experts and risk managers, they will need to develop a greater awareness of accountability for their role in risk management. While risk management professionals are accountable to their institutions, the public, their profession and the legal system for their actions, the public has no such oversight. For example, intervenors in a siting process can inject into proceedings whatever facts and opinions they choose without having to account for their accuracy or their possible negative impacts. If risk management professionals evidence disdain for the public in some circumstances, perhaps it is because the public sometimes takes on a herd mentality, expressing opinions as facts and exhibiting a tyranny of the masses.

The public needs more education in risk issues. Not so they will understand the technical facts and accept them uncritically, but so that their criticisms will be from a place of understanding that which they are criticizing. Developers and project proponents have respect for members of the public who do take the time to become knowledgeable in the depth and breadth of the problems at hand. However, many members of the public reduce societal decisions to the minuscule and self-absorbed confines of their own lives. It is not simply up to risk management professionals to learn the ways of the public. The public must also learn about the individuals and institutions which the democratic process has established to manage risks on behalf of society. There is an imbalance of awareness. Risk managers are implored to be aware of and sensitive to the views of the public, but the public is not implored to learn about technology, its benefits, its risks and the problems of managing them. In attempting to accommodate the public, we often accommodate all of the public without discriminating well between those who's viewpoints and values are evolved and well-deliberated, and those who have invested relatively little time and effort into becoming risk literate.

To these ends, public education about risk assessment and risk management is imperative. Certainly the current national emphasis in education on developing greater public awareness and literacy in science is laudable and of great benefit. However, general knowledge of science is not enough. Informed viewpoints on risk issues require an appreciation of the complexities of risk assessment and some fluency in interpreting the results of multiple, and often conflicting, scientific studies. Furthermore, no technology is simply its risks. Most technologies that come under public scrutiny provide benefits. Many times, those benefits are actually an alleviation of a risk that existed before the technology was developed. Thus, many societal decisions about risk that are framed as a risk/benefit tradeoff are actually a risk/risk evaluation. However, the risks of life before many of our current technologies existed is only comprehensible by taking a close look at the basic needs that a technology fulfills. If risk managers sometimes appear not to appreciate the public's attitudes about risk it is perhaps because the public often trivializes the benefits of technology by

assuming its existence, and excluding the risks to which they would be exposed without it.

- *A goal of risk communication should be to facilitate movement toward a negotiating position.* Project proponents who are successful in today's social arena generally are those who recognize the powerful role that public opinion plays in technological development. Though in previous decades technological development generally moved forward without broad-based public involvement, that is less so today and is very likely to be even less so in the future. Risk communication can be an effective tool for advancing technological develop if it is pursued with the intention of reaching a position whereby a project proponent and a potential host community or partner can enter into a negotiation around a given project that advances the goals and objectives of both parties. With virtual certainty, attempting to ignore the risks of a technological project will not facilitate achiving that goal. Likewise, entering into a debate with the public about who's definition of risk is the appropriate or "correct" one will only direct the dialogue away from a considering of a project's full range of impact, including those that are of benefit. The answer lie in acknowledging a project's risks, and representing those risks as fairly as possible in terms that both parties can comprehend and agree upon. Approached in this spirit, risk communication can play a role in a negotiated settlement about the suitability of a given project for a particular community, or can be helpful in technical or engineering modifications that are based on a reasoned consideration of risks.

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1.The term "decisionmaker" is very broadly defined here to include internal higher ups, local sponsors, and potential citizen intervenors.

2.This is the observation of a non-lawyer and will, no doubt, be taken with the appropriately large grain of salt.

3.This view of outcomes as being gains or losses is an alternative to the view of assessing outcomes in terms of final asset position, as is the case in most traditional expected utility analyses of risky decision making.

4.Interestingly, the more trials that are run in a simulation, the more extreme the worst-case and best-case outcomes are likely to be in spite of the fact that the likelihood of those outcomes will be very small.

5. A lexicographic choice process is one that uses a single attribute or dimension of a problem to make a decision. For example, choosing a job based solely on which job has the highest starting salary is a lexicographic choice process.

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The U.S. Army Corps of Engineers is encouraging, and in some cases requiring, greater use of risk-based analytical methods in evaluating the engineering and economic performance of its proposed investments. To this end, the Corps perceives a need to improve its communication of risk information among groups within the Corps and with its customers. There exists a considerable volume of literature on the subject of risk communication, but much of its advice is either unrelated to Corps concerns or is too general for applied problems.

A workshop comprised of a small team of national and international experts in the field of risk communication was held in concert with Corps personnel. The workshop was conducted for the purpose of highlighting ideas, concepts, and methods of risk communication and discussing the bearing on conventional application of such approaches to Corps practices. This workshop and review was conducted as part of the Corps' Risk Analysis For Water Resources Investments Research Program, managed by the Institute For Water Resources.

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